US009119304B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.: US 9,119,304 B2**
(45) **Date of Patent: Aug. 25, 2015**

(54) **LIGHT EMITTING DEVICE INCLUDING A LIGHT EMITTING ELEMENT MOUNTED ON A SUB-MOUNT**

(75) Inventors: **Yu-Sik Kim**, Anyang-si (KR); **Woo-Sung Han**, Seoul (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si, Gyeonggi-do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 270 days.

(21) Appl. No.: **13/566,291**

(22) Filed: **Aug. 3, 2012**

(65) **Prior Publication Data**

US 2013/0001606 A1 Jan. 3, 2013

Related U.S. Application Data

(63) Continuation of application No. 12/457,803, filed on Jun. 22, 2009, now Pat. No. 8,238,112.

(30) **Foreign Application Priority Data**

Jun. 24, 2008 (KR) 10-2008-0059567

(51) **Int. Cl.**
H05K 1/11 (2006.01)
H05K 1/14 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 1/0295*** (2013.01); *H01L 25/0753* (2013.01); *H01L 2224/16225* (2013.01); *H05K 2201/0949* (2013.01); *H05K 2201/09227* (2013.01); *H05K 2201/09254* (2013.01); *H05K 2201/09318* (2013.01); *H05K 2201/09663* (2013.01); *H05K 2201/09954* (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 361/782–784, 760–764, 803; 257/13, 257/88–98
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,959,316 A *	9/1999	Lowery	....	257/98
6,066,861 A *	5/2000	Hohn et al.	....	257/99

(Continued)

FOREIGN PATENT DOCUMENTS

JP	2007-048773 A	2/2007
JP	2007-116116 A	5/2007

(Continued)

OTHER PUBLICATIONS

Taiwan Office Action dated Mar. 24, 2014.

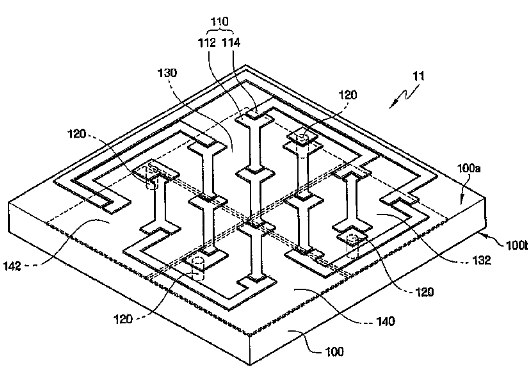
(Continued)

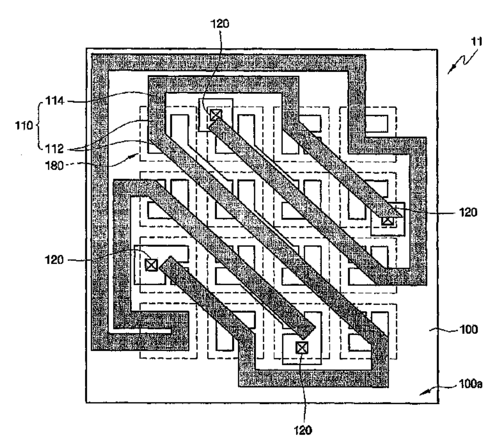
Primary Examiner — Tuan T Dinh
(74) *Attorney, Agent, or Firm* — Lee & Morse, P.C.

(57) **ABSTRACT**

A sub-mount adapted for AC and DC operation of devices mountable thereon, light emitting devices including such a sub-mount, and methods of manufacturing such a sub-mount are provided. The sub-mount includes a base substrate having first and second surfaces, a conductive pattern on the first surface, first and second pairs of first and second electrodes on the second surface and vias extending through the base substrate between the first and second surfaces. The conductive pattern includes a first set of mounting portions and two via portions along a first electrical path between the first pair of first and second electrodes, and a second set of mounting portions and two via portions along a second electrical path between the second pair of first and second electrodes, the via portions connecting respective portions of the conductive pattern to respective electrodes.

9 Claims, 26 Drawing Sheets





(51) **Int. Cl.**
H05K 1/02 (2006.01)
H01L 25/075 (2006.01)

(52) **U.S. Cl.**
CPC *H05K2201/10106* (2013.01); *H05K 2203/173* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,148,515	B1	12/2006	Huang et al.	
7,567,317	B2	7/2009	Tanaka et al.	
8,154,040	B2	4/2012	Sorg et al.	
2002/0075677	A1	6/2002	Dokoupil	
2003/0030060	A1	2/2003	Okazaki	
2004/0012027	A1*	1/2004	Keller et al.	257/79
2006/0012299	A1*	1/2006	Suehiro et al.	313/512
2006/0158130	A1	7/2006	Furukawa	
2007/0085944	A1	4/2007	Tanaka et al.	
2008/0036362	A1*	2/2008	Tanimoto et al.	313/498
2010/0012955	A1	1/2010	Sorg et al.	
2010/0230691	A1	9/2010	Inoue et al.	
2012/0190140	A1	7/2012	Sorg et al.	

FOREIGN PATENT DOCUMENTS

JP	2007-140453	A	6/2007
JP	2007-262154	A	11/2007
KR	10-2005-0060479	A	6/2005
KR	10-0652133	B1	11/2006
TW	200527722		12/1993
TW	200816530		9/1996

OTHER PUBLICATIONS

Korean Office action dated May 23, 2014 for KR 10-2008-0059567 (Kim, et al.).

Chinese Office Action for 201210396187.2 dated Jun. 9, 2015; Kim, et al.

* cited by examiner

FIG. 1A

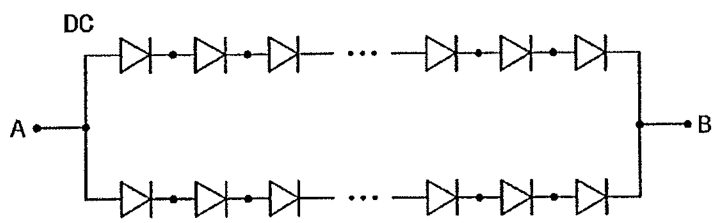


FIG. 1B

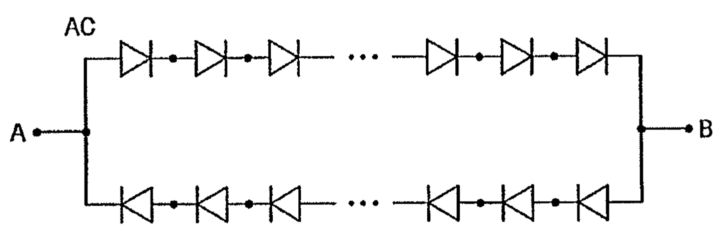


FIG. 2A

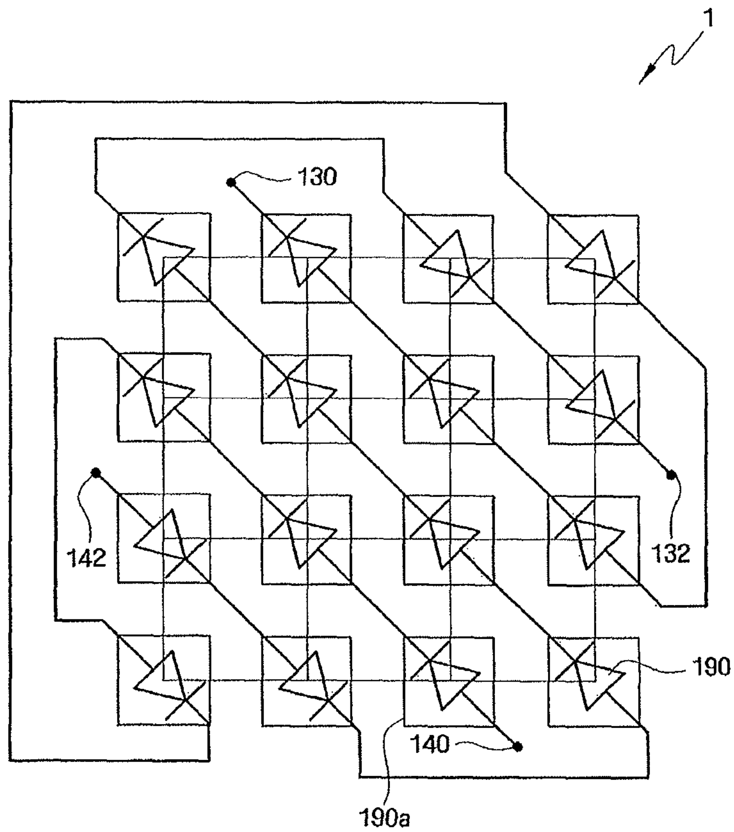

1
130
132
142
190
140
190a

FIG. 2B

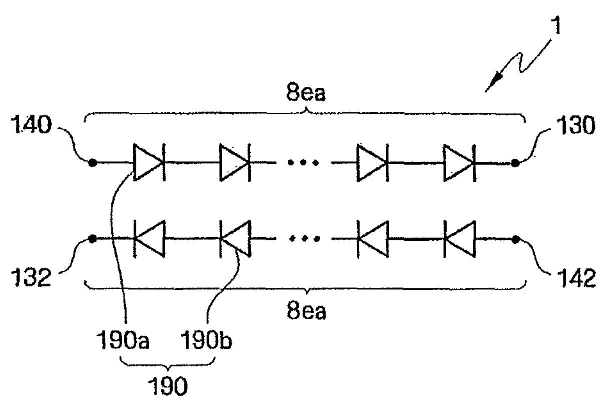

1
8ea
140
130
132
142
8ea
190a
190b
190

FIG. 3A

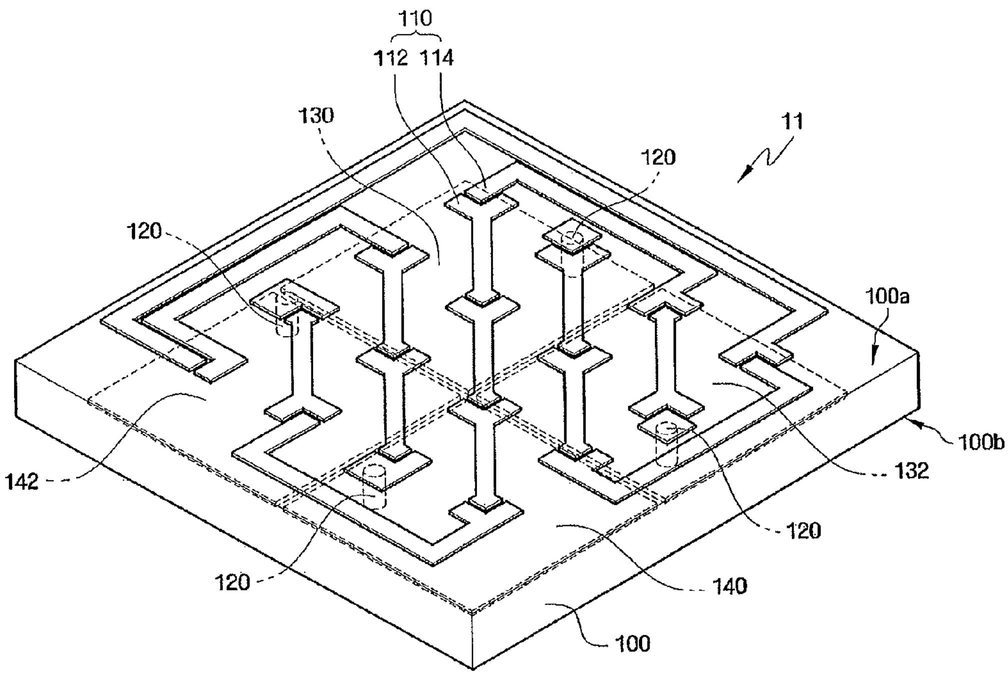


FIG. 3B

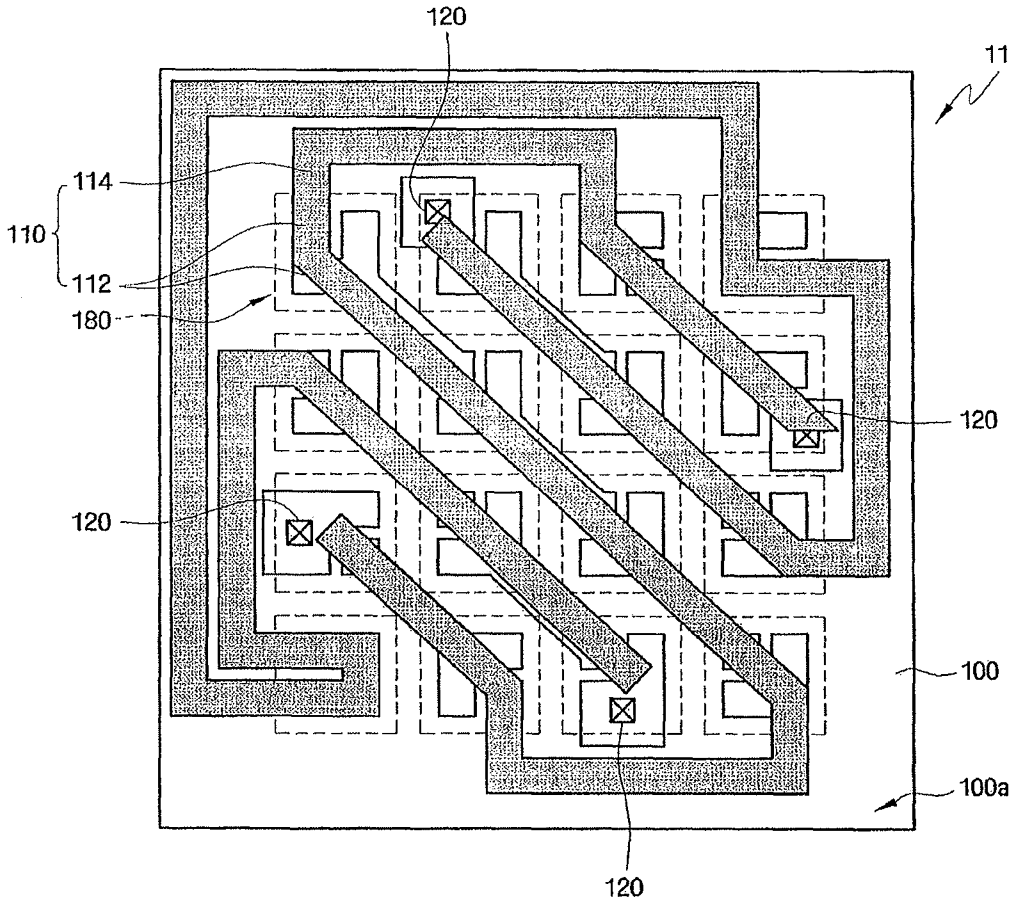


FIG. 3C

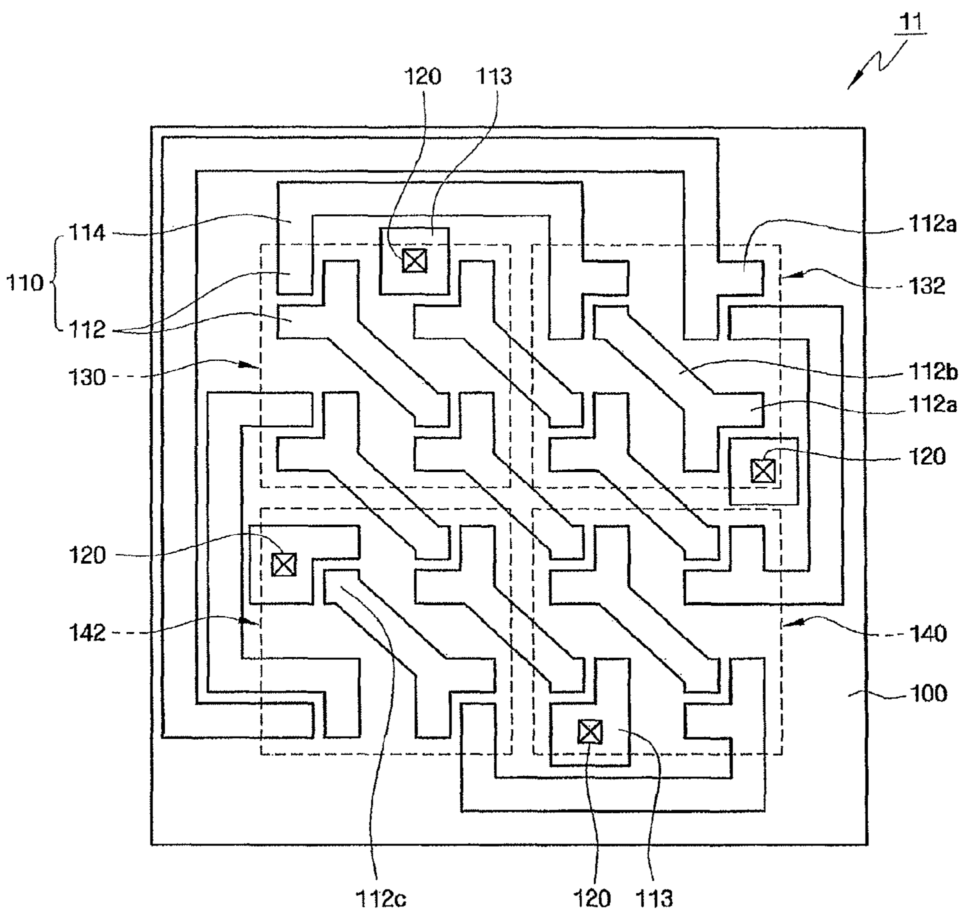

11
120
113
114
110
112
112a
132
130
112b
112a
120
120
142
140
100
112c
120
113

FIG. 3D

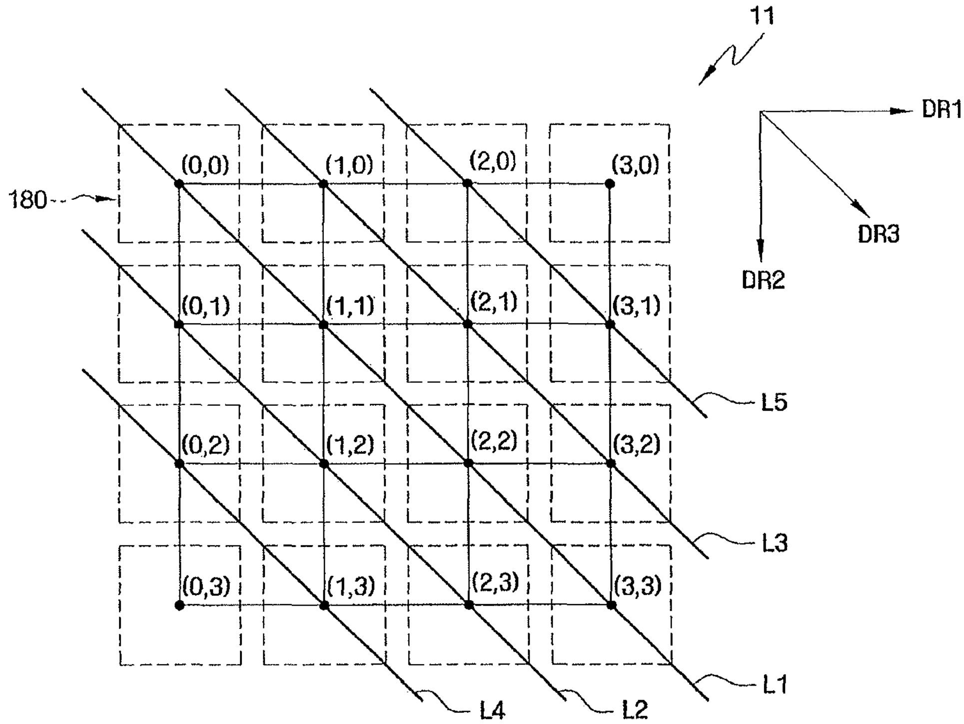

11
DR1
DR2
DR3
180
(0,0)
(1,0)
(2,0)
(3,0)
(0,1)
(1,1)
(2,1)
(3,1)
(0,2)
(1,2)
(2,2)
(3,2)
(0,3)
(1,3)
(2,3)
(3,3)
L5
L3
L1
L4
L2

FIG. 3E

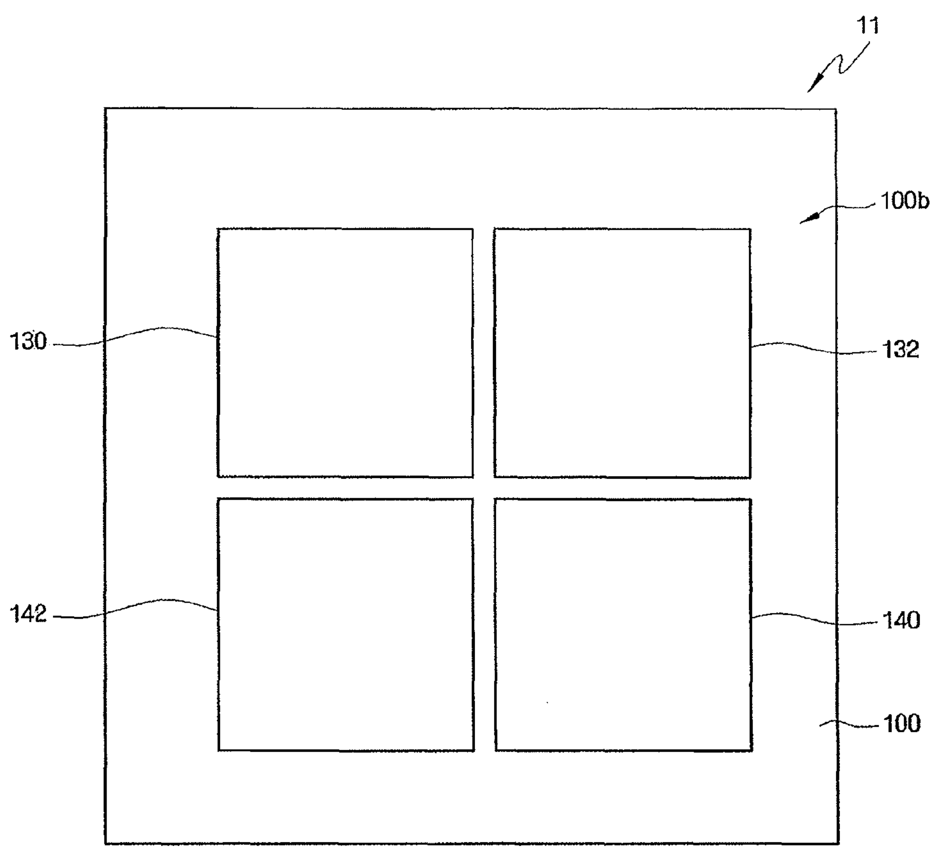


FIG. 4

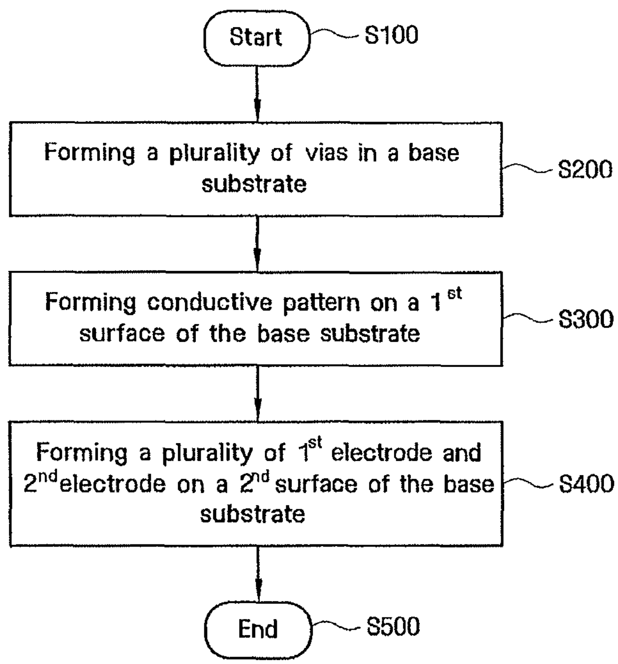

Start
S100
Forming a plurality of vias in a base substrate
S200
Forming conductive pattern on a 1st surface of the base substrate
S300
Forming a plurality of 1st electrode and 2nd electrode on a 2nd surface of the base substrate
S400
End
S500

FIG. 5

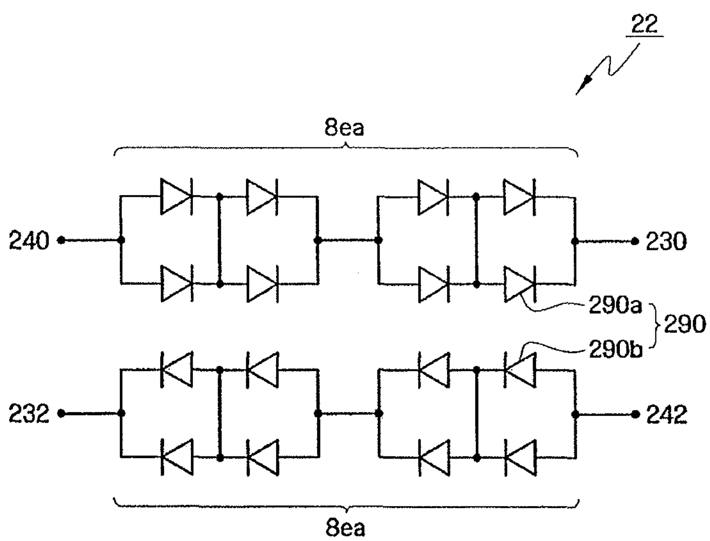


FIG. 6A

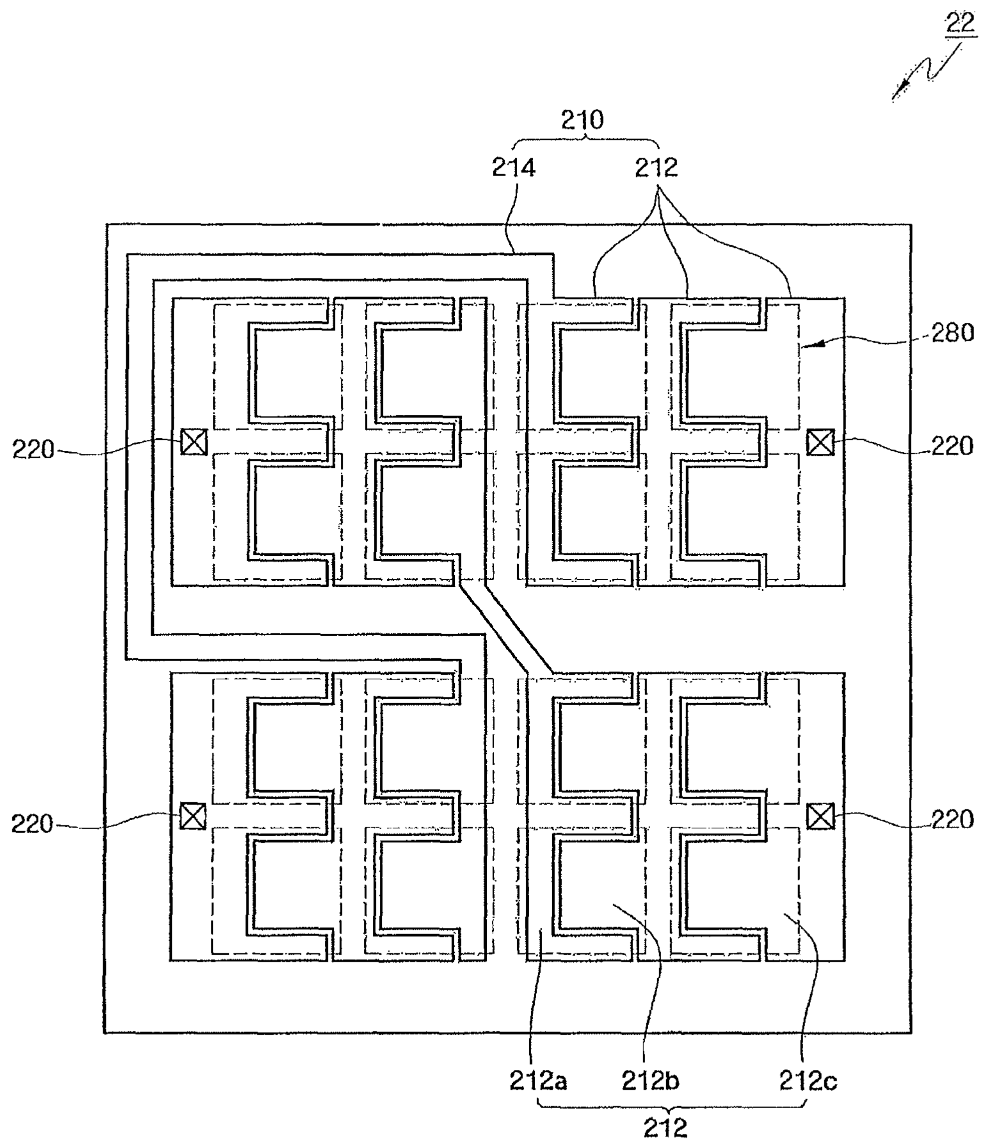


FIG. 6B

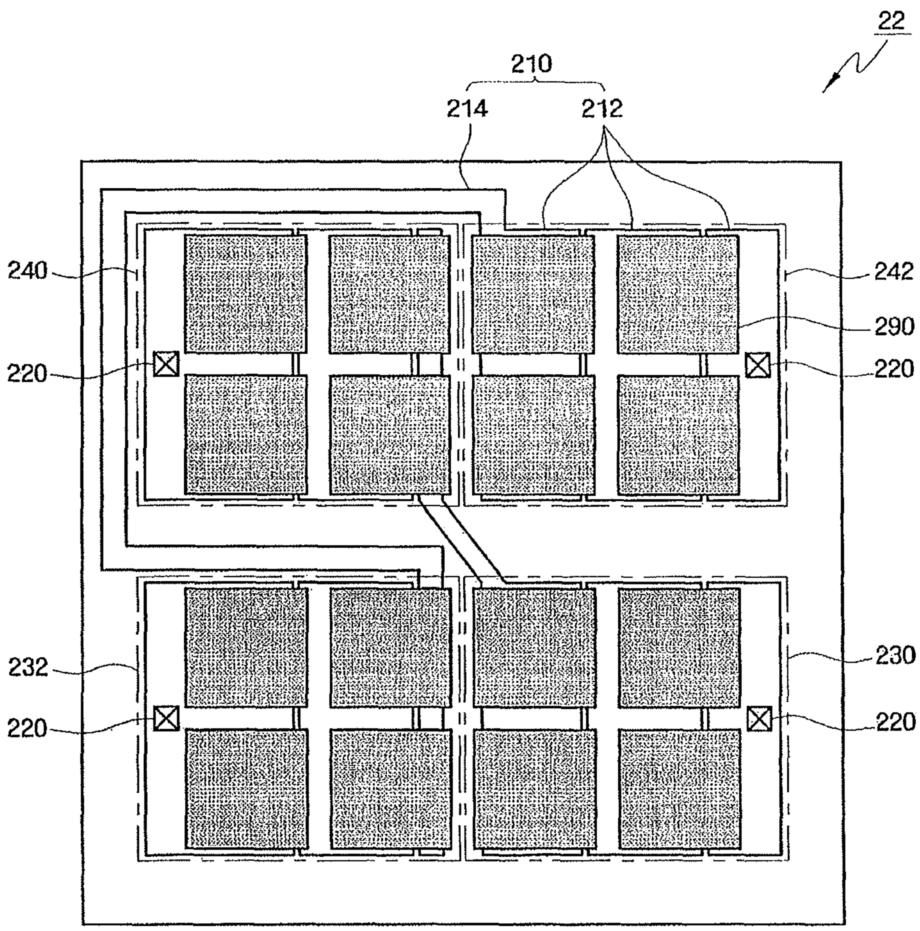


FIG. 7

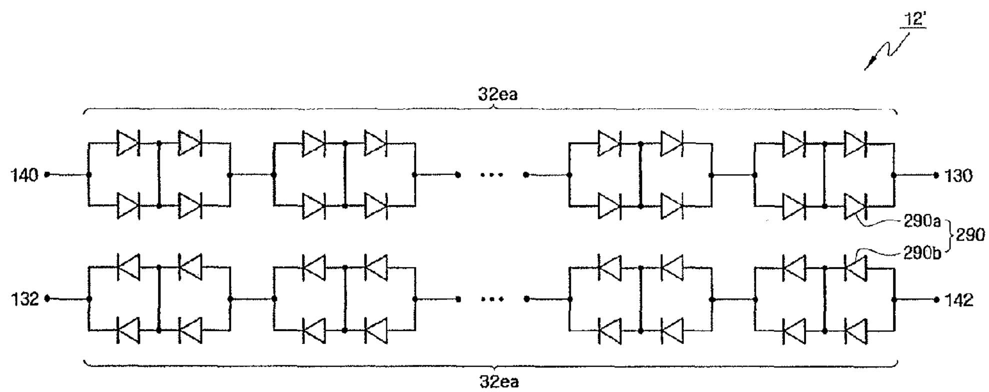


FIG. 8

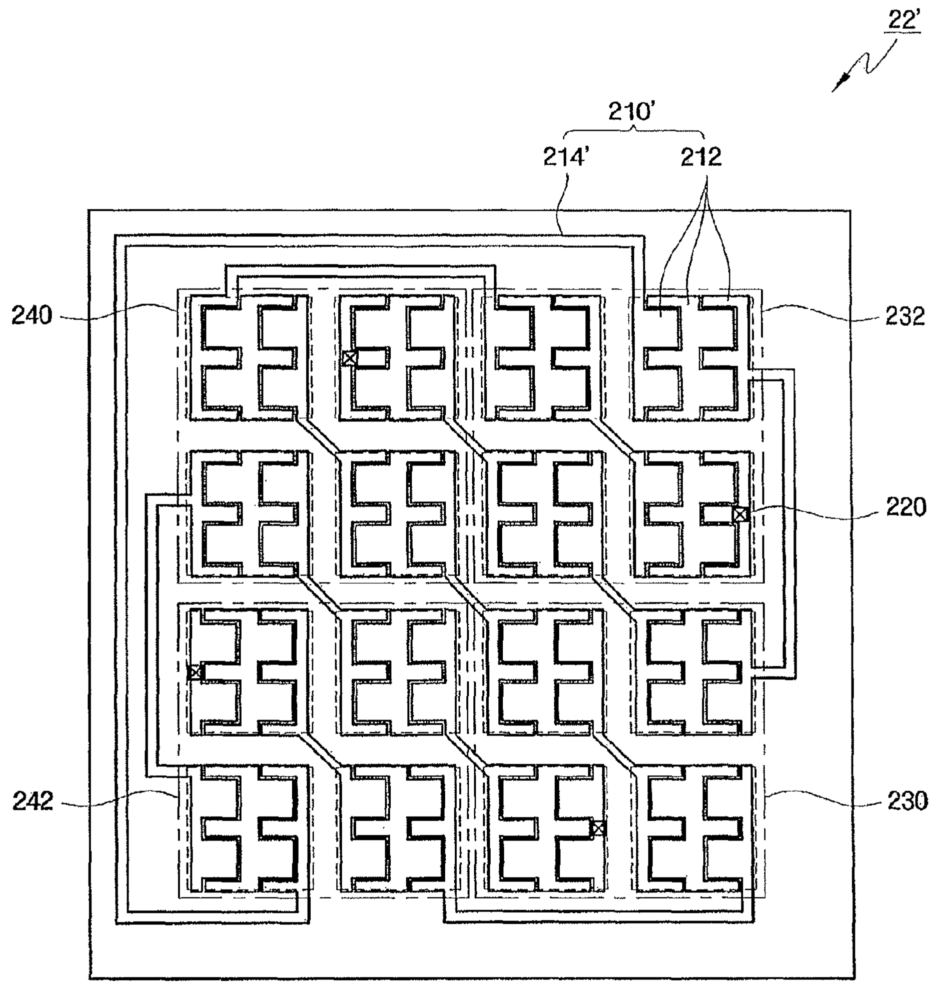


FIG. 9A

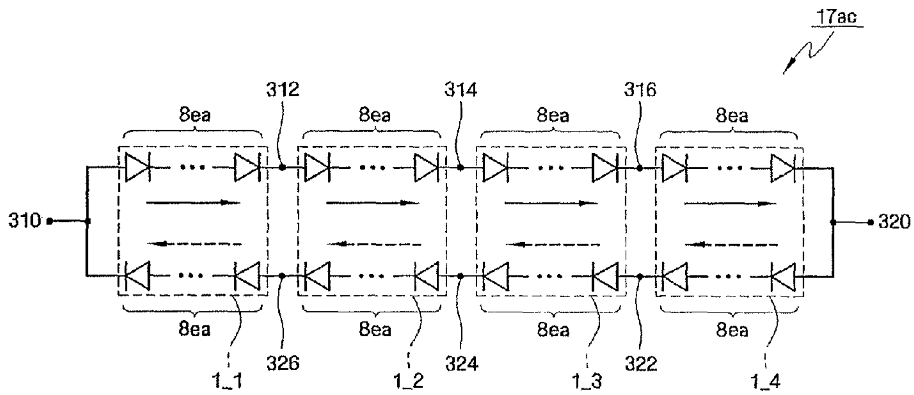

17ac
312
314
316
8ea
8ea
8ea
8ea
310
320
8ea
8ea
8ea
8ea
326
324
322
1_1
1_2
1_3
1_4

FIG. 9B

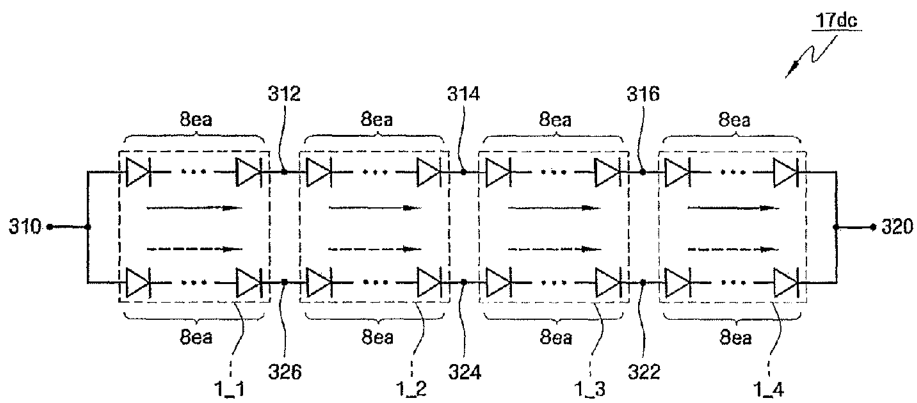

17dc
312
314
316
8ea
8ea
8ea
8ea
310
320
8ea
8ea
8ea
8ea
326
324
322
1_1
1_2
1_3
1_4

FIG. 10A

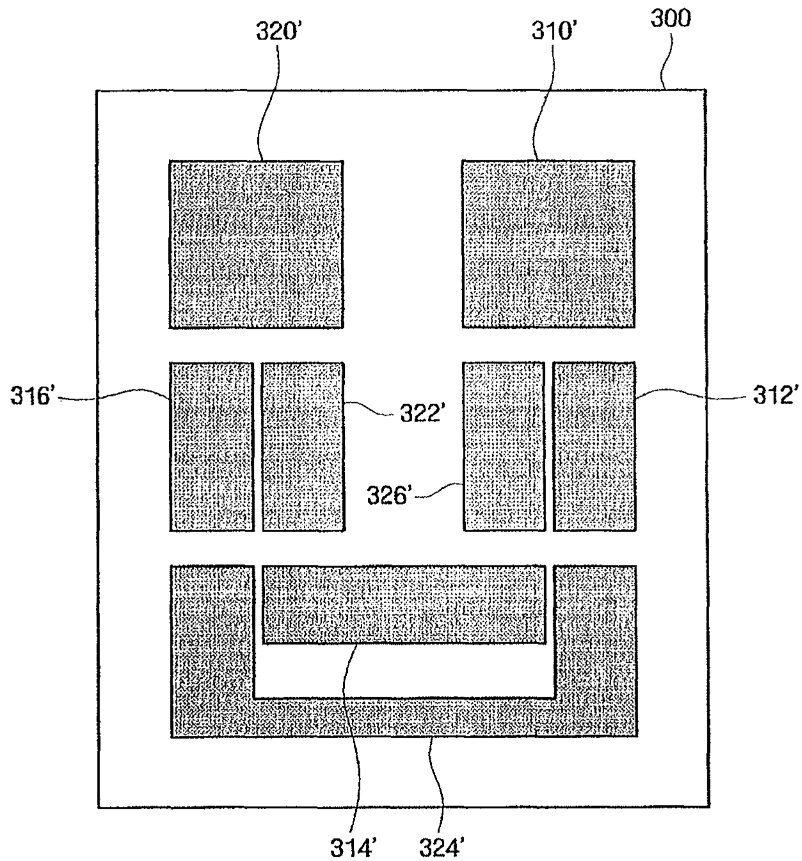


FIG. 10B

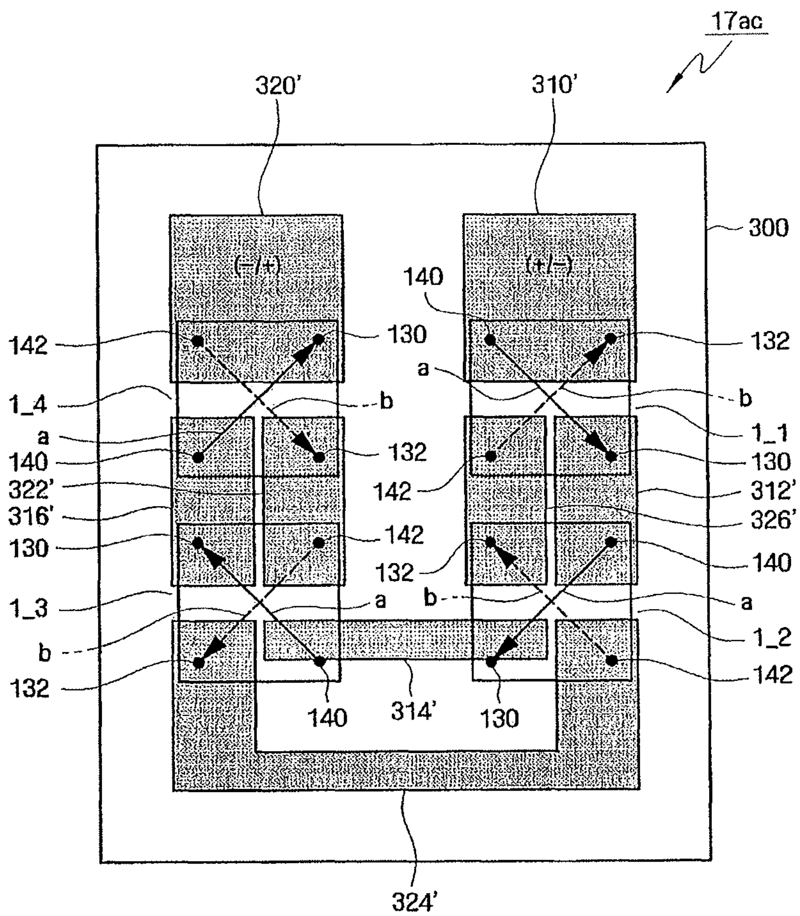

17ac
320'
310'
300
(−/+)
(+/−)
140
142
130
132
a
1_4
b
1_1
140
132
130
142
322'
312'
316'
326'
130
142
132
140
b
a
1_3
1_2
b
132
142
140
314'
130
324'

FIG. 10C

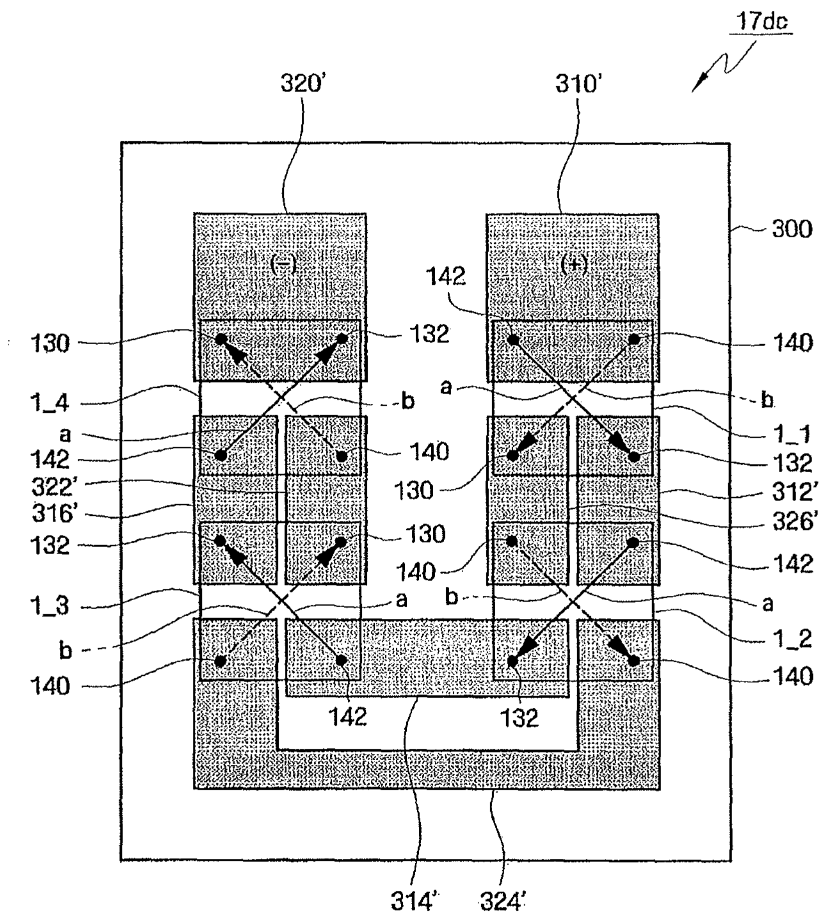

17dc
320'
310'
300
(-)
(+)
142
130
132
140
1_4
a
b
1_1
142
140
132
130
322'
312'
316'
326'
132
130
140
142
1_3
a
b
a
b
1_2
140
140
142
132
314'
324'

FIG. 11A

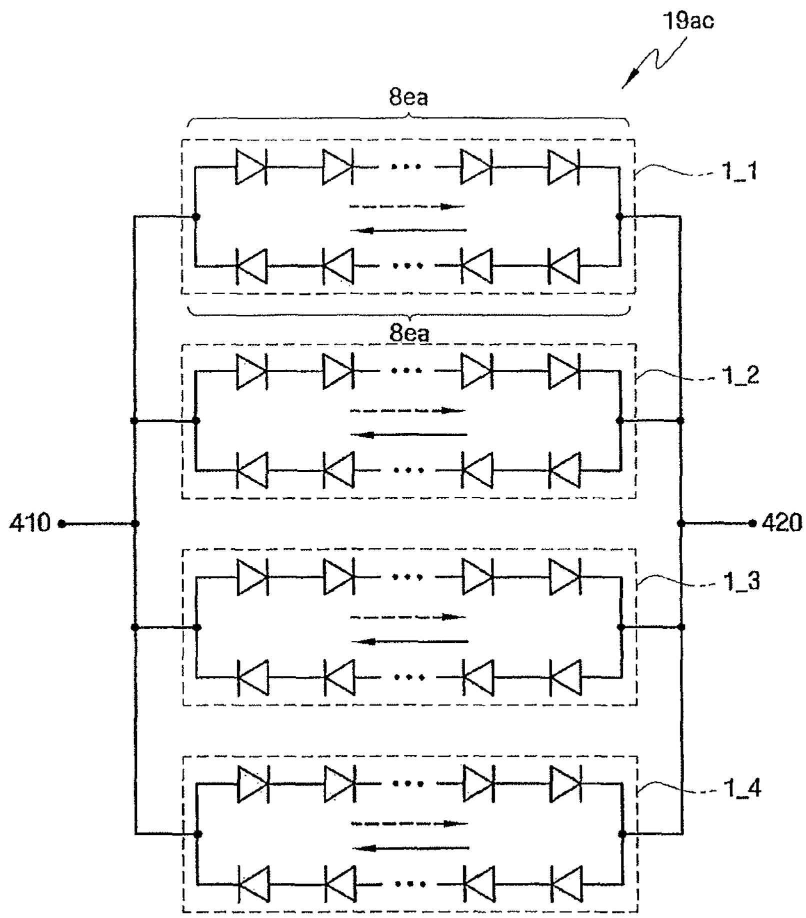


FIG. 11B

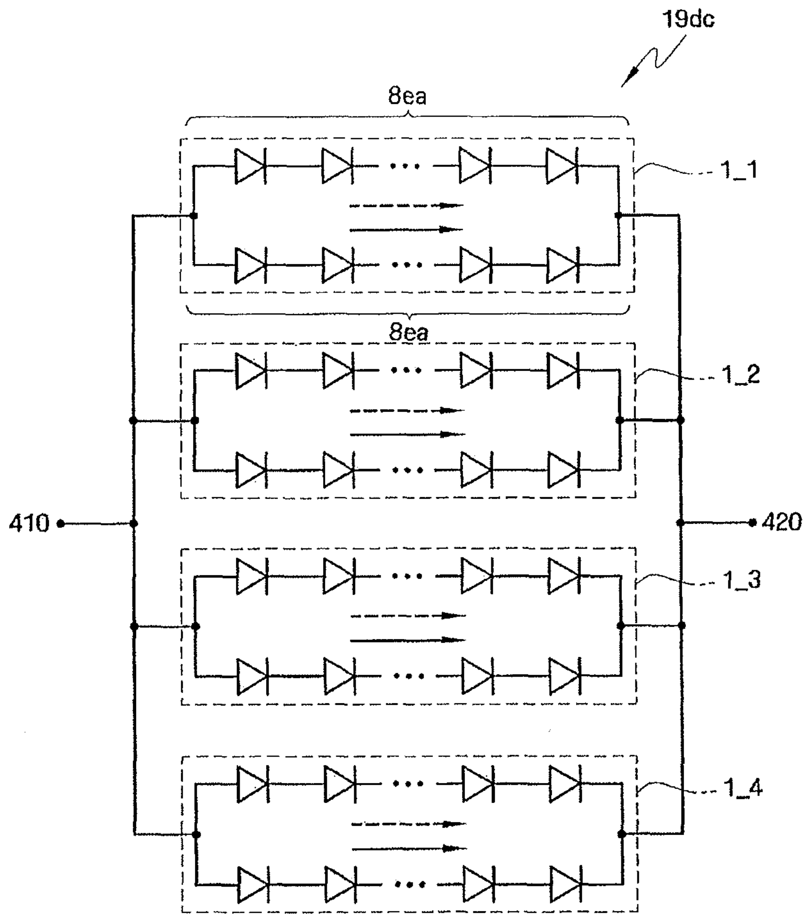


FIG. 12A

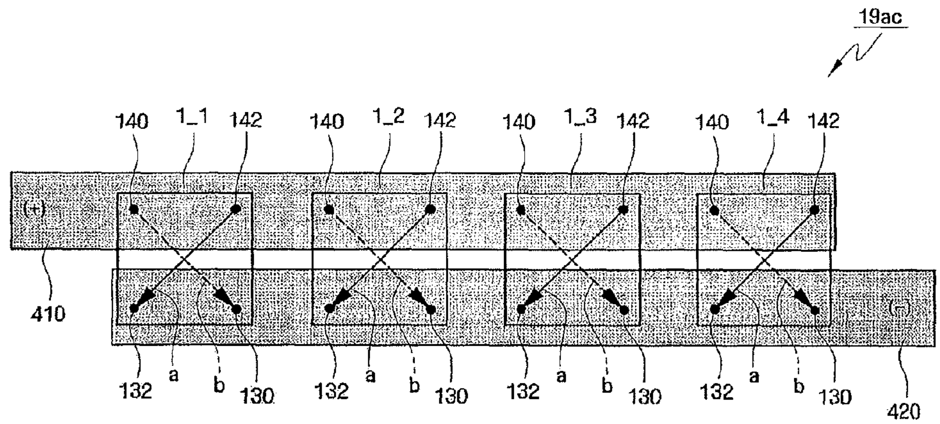


FIG. 12B

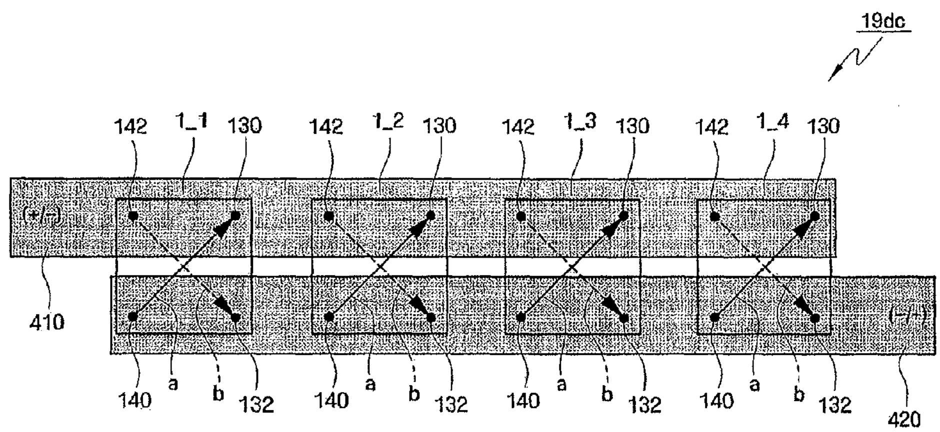


FIG. 13

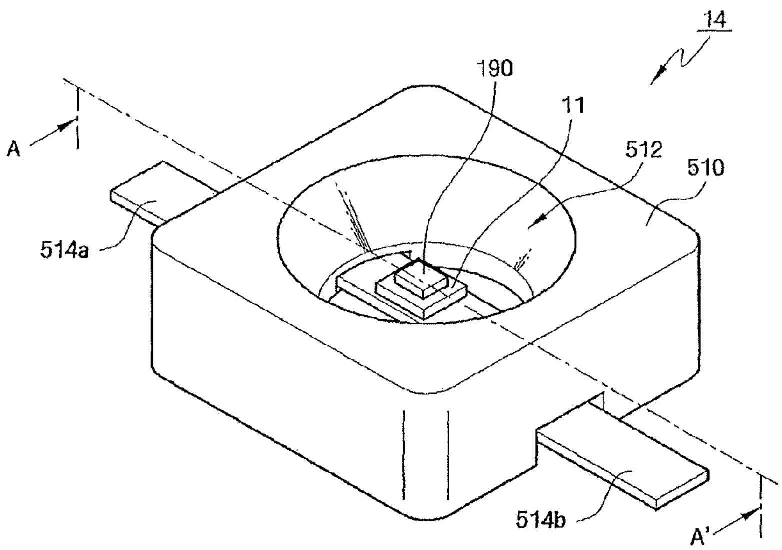


FIG. 14A

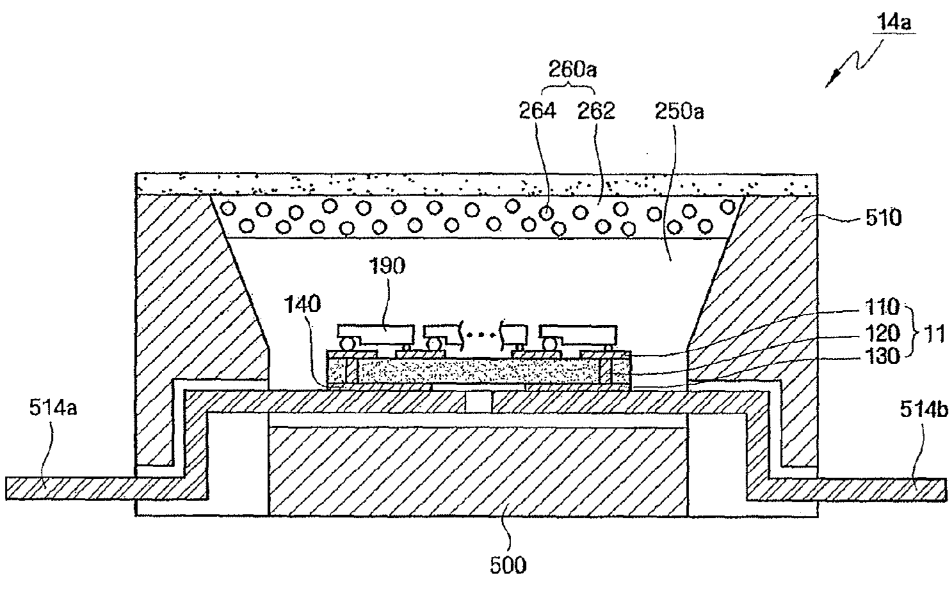


FIG. 14B

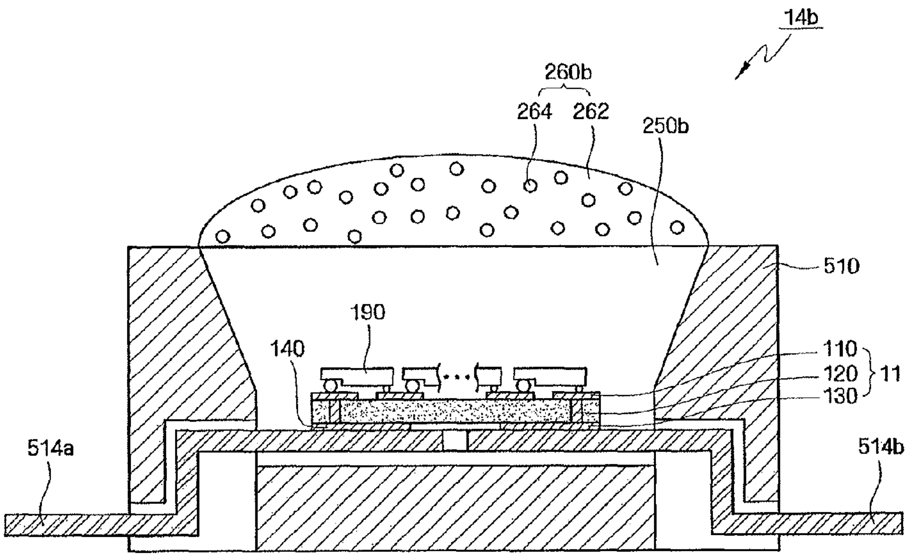


FIG. 14C

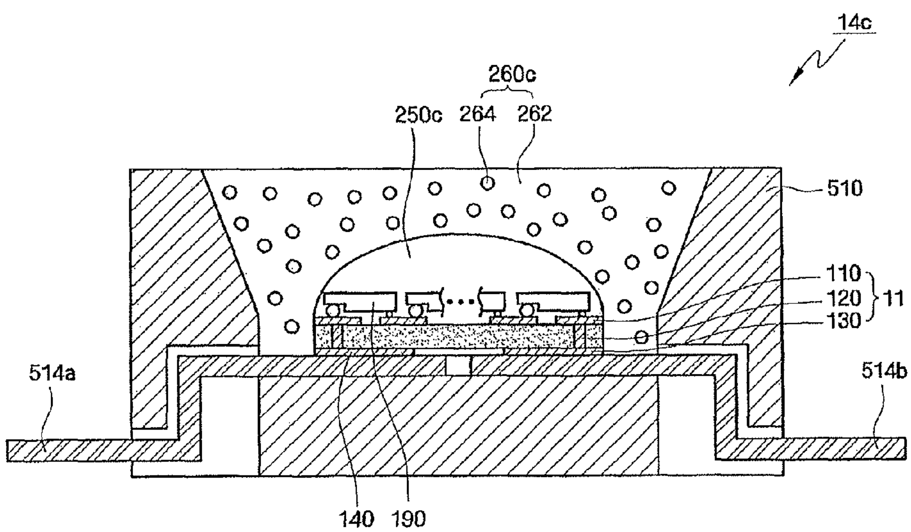


FIG. 15A

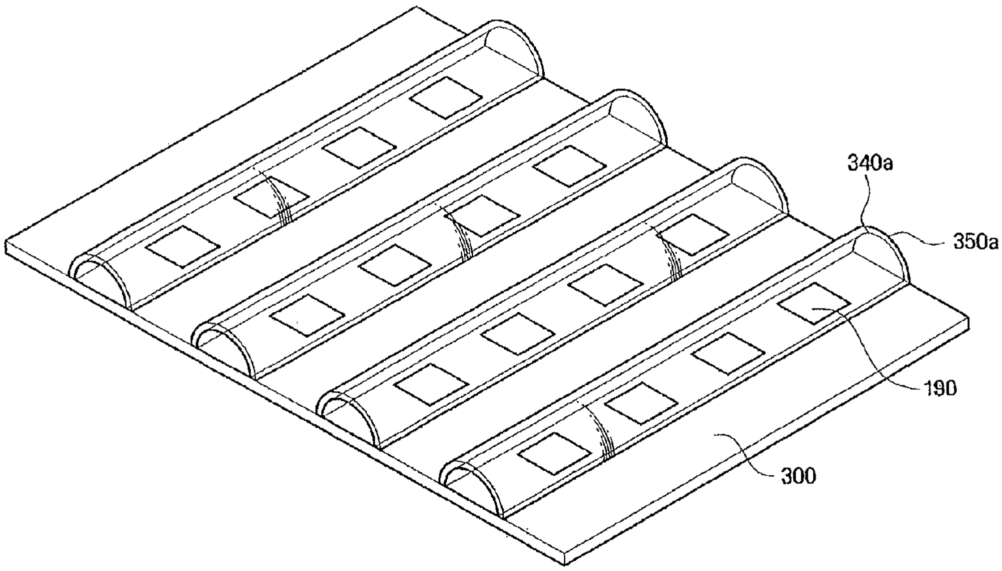


FIG. 15B

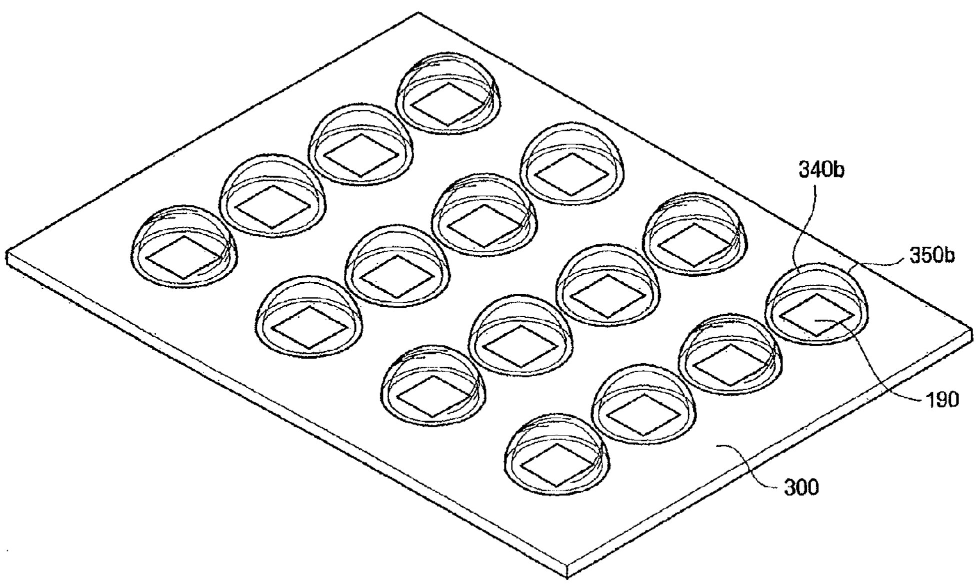


FIG. 16A

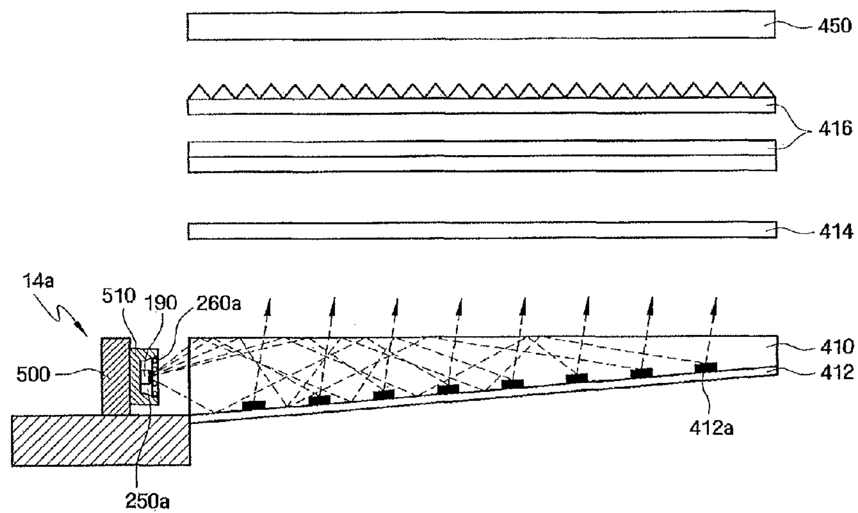


FIG. 16B

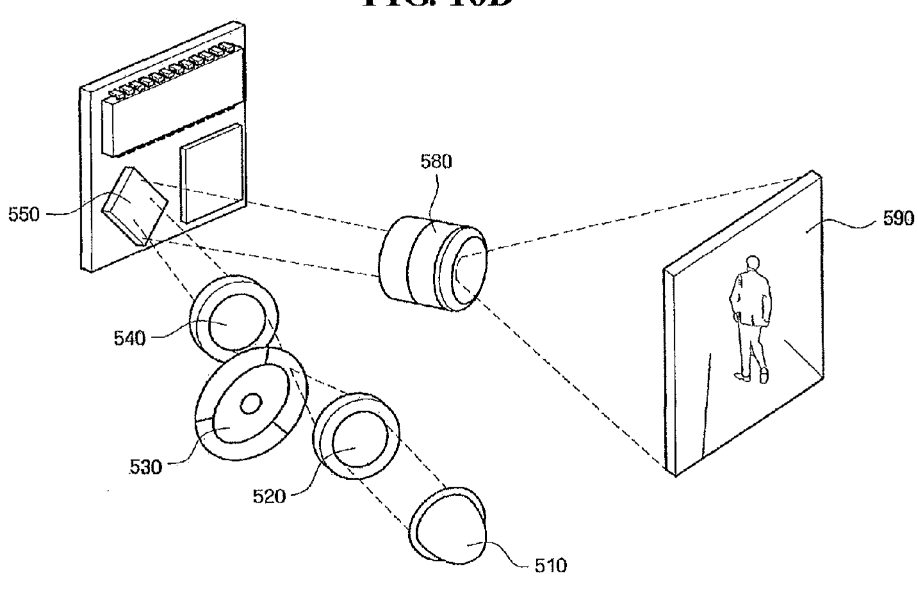


FIG. 16C

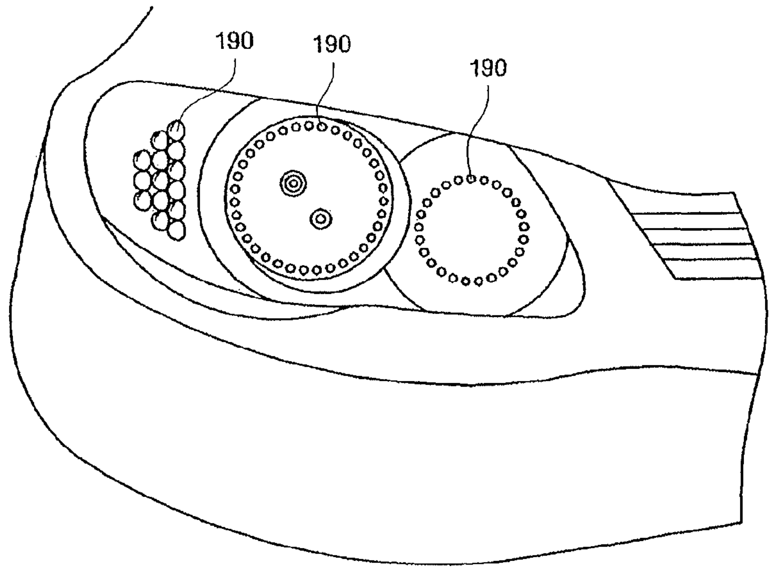


FIG. 16D

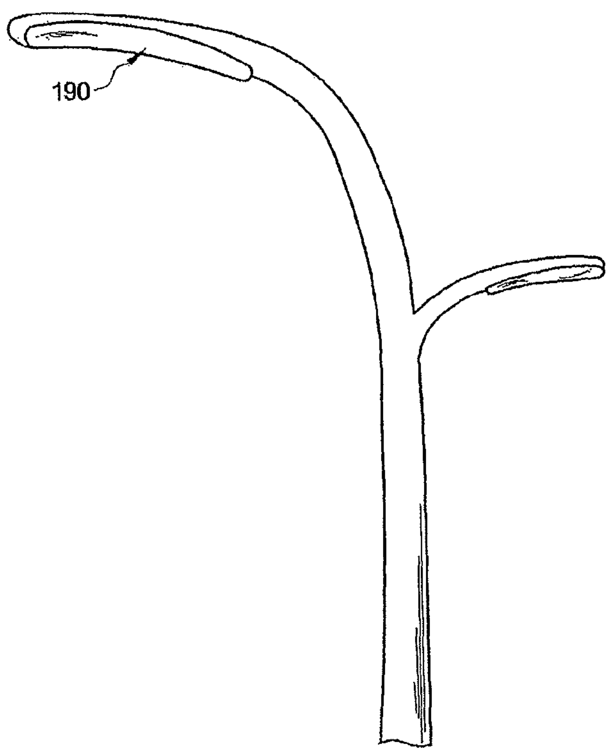
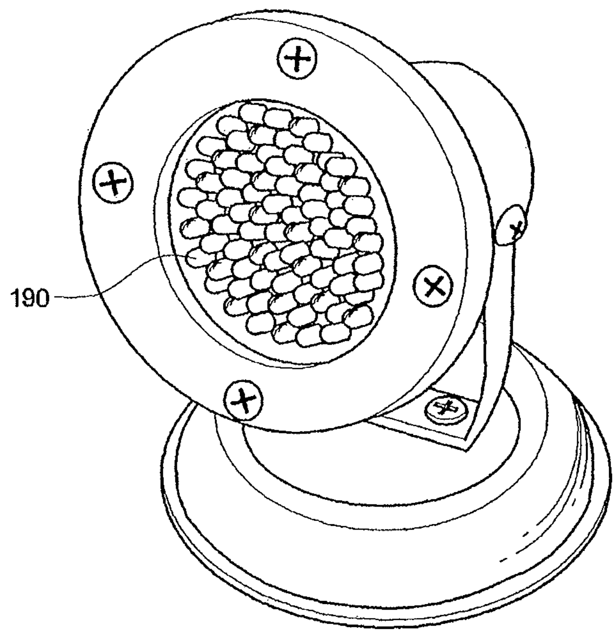


FIG. 16E



LIGHT EMITTING DEVICE INCLUDING A LIGHT EMITTING ELEMENT MOUNTED ON A SUB-MOUNT

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation application based on pending application Ser. No. 12/457,803, filed Jun. 22, 2009, the entire contents of which is hereby incorporated by reference.

BACKGROUND

1. Field

Embodiments relate to sub-mounts, light emitting elements, light emitting devices including such light emitting elements on a sub-mount, and methods of manufacturing such sub-mounts and/or light emitting devices. More particularly, embodiments relate to sub-mounts and light emitting devices employing sub-mounts that are optimized for both alternating current (AC) and direct current (DC) operation.

2. Description of the Related Art

Light emitting elements, e.g., light emitting diodes (LEDs), are employed in a variety of applications, e.g., displays, digital clocks, remote controls, watches, calculators, cell phones, indicator lights, backlights, etc. More particularly, e.g., light emitting diodes may be employed as a liquid crystal display (LCD) backlight unit, a camera flash, display screen, etc.

LEDs generally emit light as a result of electroluminescence, i.e., recombination of electron-hole pairs. Electron-hole pairs may be recombined as a result of electric current at a semiconductor p-n junction. When electrons and holes recombine, energy may be given off in the form of photons.

In general, a light emitting element, e.g., LEDs, may be packaged as a single chip. A plurality of such single chip LEDs may be connected in series or in parallel in an apparatus, e.g., a light source. More particularly, the plurality of LEDs may be mounted on a substrate.

While such LEDs are already being used in a wide variety of applications, there is a need for sub-mounts and/or light emitting devices including sub-mounts that are optimized for both AC and DC operation of the LEDs.

SUMMARY

Embodiments are therefore directed to sub-mounts and light emitting devices employing sub-mounts, which substantially overcome one or more of the problems due to the limitations and disadvantages of the related art.

It is therefore a feature of an embodiment to provide sub-mounts that are optimized for both alternating current (AC) and direct current (DC) operation of elements mounted thereon.

It is therefore a separate feature of an embodiment to provide light emitting devices including a sub-mount, which are optimized for both alternating current (AC) and direct current (DC) of elements mounted thereon.

It is therefore a separate feature of an embodiment to provide a method of fabricating a sub-mount that is optimized for both alternating current (AC) and direct current (DC) operation.

It is therefore a separate feature of an embodiment to provide a method of fabricating a light emitting device including a sub-mount, which is optimized for both alternating current (AC) and direct current (DC) operation.

At least one of the above and other features and advantages may be realized by providing a sub-mount adapted for AC and DC operation of devices mountable thereon, the sub-mount including a base substrate including a first surface and a second surface, the first surface being different from the second surface, a conductive pattern on the first surface, a first pair of first and second electrodes on the second surface of the base substrate, a second pair of first and second electrodes on the second surface of the base substrate, and a plurality of vias extending through the base substrate between the first surface and the second surface, wherein the conductive pattern includes a first set of mounting portions and two via portions along a first electrical path between the first pair of first and second electrodes, and a second set of mounting portions and two via portions along a second electrical path between the second pair of first and second electrodes, the first path being independent of the second path, and each of the via portions connecting respective portions of the conductive pattern to a respective one of the electrodes of the first and second pair of first and second electrodes through a respective one of the vias.

The conductive pattern may further include wiring portions adapted to connect respective mounting portions together.

Each of the mounting portions may include a mounting sub-portion and a connecting sub-portion.

At least some of the mounting portions may include a substantially Y-like shape with the mounting sub-portions having a substantially V-like shape and the connecting sub-portions extending toward the mounting sub-portion of an adjacent one of the mounting portions along the respective electrical path.

Each of the mounting sub-portions may correspond to a mounting region of the sub-mount, each of the mounting regions **1** being adapted to mount a light emitting device thereon.

Each of the connecting sub-portions may be associated with two of the mounting regions.

The mounting sub-portions may be arranged in a matrix pattern.

The connecting sub-portions may extend diagonally between adjacent ones of the mounting sub-portions.

The first electrical path may flow from one of the first and second electrodes of the first pair of electrodes through the a first via of the plurality of vias, a first via portion of the corresponding two via portions, the first set the mounting portions, a second via portion of the corresponding two via portions, a second via of the plurality of vias and the other of the first and second electrodes of the first pair of electrodes, and the second electrical path may flow from one of the first and second electrodes of the second pair of electrodes through a third via of the plurality of vias, a via portion of the corresponding two via portions, the second set of mounting portions, a second via portion of the corresponding two via portions, a fourth via of the plurality of vias, and the other of the first and second electrodes of the second pair of electrodes.

The first and second pair of first and second electrodes may be arranged in a matrix pattern on the second surface, and the first pair of first and second electrodes is arranged diagonally along a first direction and the second pair of first electrodes is arranged diagonally along a second direction.

Each of the mounting portions may include three mounting sub-portions arranged adjacent to each other, each of the mounting sub-portions being spaced apart from each other.

Each of the mounting sub-portions may include an E-like and/or an inverse E-like shaped portion.

Each of the mounting portions may correspond to four mounting regions of the sub-mount, each of the mounting regions may be adapted to mounting a light emitting device thereon.

The mounting portions may be arranged in a matrix pattern.

At least one of the above and other features and advantages may be separately realized by providing a light emitting device, including at least one sub-mount including a base substrate, a first pair of first and second electrodes, a second pair of first and second electrodes, a conductive pattern and a plurality of vias, a first set of light emitting devices mounted on the sub-mount, the first set of light emitting devices being connected between the first pair of first and second electrodes of the sub-mount, a second set of light emitting devices mounted on the sub-mount, the second set of light emitting devices being connected between the second pair of first and second electrodes of the sub-mount, a first power supply electrode connected to one of the first and second electrodes of the first pair of electrodes and one of the first and second electrodes of the second pair of electrodes on the sub-mount, and a second power supply electrode connected to the other of the first and second electrodes of the first pair of electrodes and the other of the first and second electrodes of the second pair of electrodes on the sub-mount, wherein the sub-mount is adapted for AC and DC operation of the light emitting devices based on which one of the first and second electrodes of each pair of electrodes is connected to the to the first power supply electrode and the second power supply electrode.

The light emitting devices of each of the first and second sets of light emitting devices may be arranged in series and/or in parallel with each other.

The first and second sets of light emitting devices may be mounted on the sub-mounts in a matrix pattern.

The light emitting device may further include a plurality of the sub-mounts, and a circuit substrate including a plurality of connecting patterns, the first power supply electrode and the second power supply electrode arranged thereon, wherein the connecting patterns may be adapted to electrically connect a plurality of the sub-mounts along an electrical path between the first power supply electrode and the second power supply electrode.

The light emitting device may include a substrate on which the first power supply electrode and the second power supply electrode are arranged, wherein a plurality of the sub-mounts are arranged on the substrate such that, for each of the sub-mounts, one of the first and second electrodes of the first electrode pair is connected to the first power supply electrode and the other of the first and second electrodes of the second electrode pair is connected to the second power supply electrode, and one of the first and second electrodes of the second electrode pair is connected to the second power supply electrode and the other of the first and second electrodes of the second electrode pair is connected to the second power supply electrode.

The first power supply electrode and the second power supply electrode may extend parallel to each other on the substrate.

Each of the light emitting devices of the first set and the second set of light emitting devices may be a light emitting diode.

At least one of the above and other features and advantages may be separately realized by providing a sub-mount employable for electrically connecting a plurality of light emitting devices in series and/or in parallel on a mounting substrate, the sub-mount including a base substrate, a conductive pattern on the base substrate, a first pair of first and second electrodes on the base substrate, a second pair of first and second electrodes on the base substrate, and a plurality of vias extending through the base substrate, wherein the conductive pattern includes a first set of mounting portions defining a first electrical path between the first pair of first and second electrodes through first and second ones of the plurality of vias, and a second set of mounting portions defining a second electrical path between the second pair of first and second electrodes through third and fourth ones of the plurality of vias, the first path being independent of the second path, when the sub-mount is arranged in a first orientation on the mounting substrate, the plurality of light emitting devices mountable on the first set of mounting portions and the plurality of light emitting devices mountable on the second set of mounting portions thereon are electrically connected such that current flows through the first set of light emitting devices and the second set of light emitting devices in a forward bias direction, and when the sub-mount is arranged in a second orientation on the mounting substrate, the plurality of light emitting devices mountable on the first set of mounting portions and the plurality of light emitting devices mountable on the second set of mounting portions thereon are electrically connected such that current flows through the first set of light emitting devices in a forward bias direction and current flows through the second set of light emitting devices in a reverse bias direction, the first orientation being different from the second orientation.

The first orientation may be rotated 90 degrees relative to the second orientation.

At least one of the above and other features and advantages may be separately realized by providing a method of manufacturing a sub-mount adapted for AC and DC operation of devices mountable thereon, the method including forming a plurality of vias in a base substrate, forming a conductive pattern on a first surface of the base substrate, forming a first pair of first and second electrodes on a second surface of the base substrate, forming a second pair of first and second electrodes on the second surface of the base substrate, wherein the vias extend through the base substrate between the first surface and the second surface, the conductive pattern includes a first set of mounting portions and two via portions along a first electrical path between the first pair of first and second electrodes, and a second set of mounting portions and two via portions along a second electrical path between the second pair of first and second electrodes, the first path being independent of the second path, and each of the via portions connecting respective portions of the conductive pattern to a respective one of the electrodes of the first and second pair of first and second electrodes through a respective one of the vias.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages will become more apparent to those of ordinary skill in the art by describing in detail exemplary embodiments with reference to the attached drawings, in which:

FIG. **1**A illustrates a schematic diagram of a light emitting device including a plurality of light emitting diodes adapted for DC operation according to an exemplary embodiment;

FIG. **1**B illustrates a schematic diagram of a light emitting device including a plurality of light emitting diodes adapted for AC operation according to an exemplary embodiment;

FIGS. **2**A and **2**B illustrate schematic diagrams of electrical paths between two pairs of electrodes of a light emitting device according to an exemplary embodiment;

FIG. **3**A illustrates a perspective elevational view of an exemplary sub-mount according to an exemplary embodiment;

FIG. **3**B illustrates a partial schematic diagram, including mounting regions, from a top of the exemplary sub-mount of FIG. **3**A;

FIG. **3**C illustrates a partial schematic diagram, including electrodes, from a top of the sub-mount of FIG. **3**A;

FIG. **3**D illustrates a schematic diagram of an exemplary arrangement of mounting regions of the sub-mount of FIG. **3**A;

FIG. **3**E illustrates a schematic diagram from a bottom of the exemplary sub-mount of FIG. **3**A;

FIG. **4** illustrates a flow chart of an exemplary method of forming the exemplary sub-mount of FIGS. **3**A-**3**E according to an exemplary embodiment;

FIG. **5** illustrates a schematic diagram of electrical paths between two pairs of electrodes of a light emitting device according to another exemplary embodiment;

FIGS. **6**A and **6**B illustrate planar views from a top of an exemplary sub-mount without and with elements mounted thereon, respectively, according to another exemplary embodiment;

FIG. **7** illustrates a schematic diagram of electrical paths between two pairs of electrodes of a light emitting device according to another exemplary embodiment;

FIG. **8** illustrates a schematic diagram from a top of an exemplary sub-mount according to another exemplary embodiment;

FIGS. **9**A and **9**B illustrate schematic diagrams of electrical paths of light emitting devices adapted for AC and DC operation, respectively;

FIG. **10**A illustrates a block diagram of a circuit substrate employable for implementing the exemplary light emitting devices of FIGS. **9**A and **9**B according to another exemplary embodiment;

FIGS. **10**B and **10**C illustrate block diagrams of the circuit substrate of FIG. **10**A including sub-mounts mounted thereon for AC and DC operation of the light emitting devices of FIGS. **9**A and **9**B, respectively, according to another exemplary embodiment;

FIGS. **11**A and **11**B illustrate schematic diagrams of electrical paths of light emitting devices adapted for AC and DC operation, respectively;

FIGS. **12**A and **12**B illustrate block diagrams of the exemplary arrangement of sub-mounts on power supply electrodes for implementing the light emitting devices of FIGS. **11**A and **11**B, respectively, according to another exemplary embodiment;

FIG. **13** illustrates an elevational schematic diagram of an exemplary light emitting device including the sub-mount **11** of FIGS. **3**A through **3**E;

FIGS. **14**A, **14**B, and **14**C illustrate cross-sectional views of the exemplary light emitting device of FIG. **13** including exemplary arrangements of phosphor therein;

FIGS. **15**A and **15**B illustrate exemplary arrangements of phosphor on the circuit substrate of FIGS. **10**A through **10**C; and

FIGS. **16**A, **16**B, **16**C, **16**D, and **16**E illustrate exemplary illuminating devices employing a light emitting device according to one or more embodiments.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Korean Patent Application No. 10-2008-0059567, filed on Jun. 24, 2008, in the Korean Intellectual Property Office, and entitled: "SUB-MOUNT, LIGHT EMITTING DEVICE USING THE SAME AND FABRICATING METHOD OF SUB-MOUNT, FABRICATION METHOD OF LIGHT EMITTING DEVICE USING THE SAME," is incorporated by reference herein in its entirety.

Embodiments of one or more aspects of the invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are illustrated. Aspects of the invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

In the figures, the dimensions of layers and regions may be exaggerated for clarity of illustration. It will also be understood that when an element is referred to as being "on" another element, it can be directly on the other element, or intervening elements may also be present. Further, it will be understood that when an element is referred to as being "under" another element, it may be directly under, and one or more intervening element may also be present. In addition, it will also be understood that when an element is referred to as being "between" two elements, it may be the only element between the two elements, or one or more intervening elements may also be present. Additionally, it will be understood that when an element is referred to as being "between" two elements, it may be physically arranged between facing/overlapping portions of the two elements, it may be physically arranged such that one of the elements is below it and the other element is above it, or it may be such that it is along a path of, e.g., current flow between the two elements. Like reference numerals refer to like elements throughout the specification.

Embodiments described herein provide sub-mounts employable, e.g., in light emitting devices and light emitting devices employing sub-mounts adapted to electrically connect a plurality of light emitting elements to operate under direct current (DC) and alternating current (AC) conditions.

FIG. **1**A illustrates a schematic diagram of a light emitting device including a plurality of light emitting diodes adapted for DC operation according to an exemplary embodiment. Referring to FIG. **1**A, during DC operation, all the LEDs along path **1** and path **2** between node A and node B may be turned on or turned off together.

FIG. **1**B illustrates a schematic diagram of a light emitting device including a plurality of light emitting diodes adapted for AC operation according to an exemplary embodiment. Referring to FIG. **1**B, during AC operation, the LEDs along the path **1** and the LEDs along the path **2** may be alternately turned off and on. More particularly, e.g., when the LEDs along the path **1** are turned on, the LEDs along the path **2** may be turned off, and when the LEDs along the path **1** are turned off, the LEDs along the path **2** may be turned on. In embodiments in which the LEDs are arranged in a matrix pattern within a light emitting device, e.g., a display, the LEDs may operate according to a dot inversion method, which may improve image quality of the light emitting device. Under the dot inversion method, when a respective one of the LEDs is on, corresponding ones of the other LEDs including sides facing a corresponding side of the respective LED are off. More particularly, e.g., under the dot inversion method, when a LED arranged at (1,1) is on, LEDs arranged at (1,0), (1,2), (0,1) and (2,1) are off, and when the LED arranged at (1,1) is off, LEDs arranged at (1,0), (1,2), (0,1) and (2,1) are on.

FIGS. **2**A and **2**B illustrate schematic diagrams of electrical paths of a light emitting device **1** adapted for AC and DC operation according to an exemplary embodiment. More particularly, in embodiments, the light emitting device **1** may include at least two pairs of electrodes adapted to enable AC and DC operation of the light emitting device **1**. Referring to FIGS. **2**A and **2**B, the light emitting device **1** may include a plurality of LEDs **190**, a first pair of electrodes **130** and **140**, and a second pair of electrodes **132** and **142**.

The LEDs **190** may include a first group of LEDs **190***a* and a second group of LEDs **190***b*. More particularly, the LEDs **190***a* between the first pair of electrodes **130** and **140** may be electrically connected together in series, and the LEDs **190***b* between second pair of electrodes **132** and **142** may be electrically connected together in series. In embodiments, the plurality of electrode pairs, e.g., the two pairs of electrodes **130**, **140**, and **132**, **142** may be driven in a manner that enables the LEDs **190***a*, **190***b* of the light emitting device **1** to operate under both AC and DC conditions. In the exemplary embodiment of FIGS. **2**A and **2**B, eight LEDs **190***a* are illustrated between the first pair of electrodes **130**, **140** and eight LEDs **190***b* are illustrated between the second pair of electrodes **132**, **142**. Embodiments are not limited, however, to such a number of LEDs between the pairs of electrodes. The LEDs **190***a*, **190***b* may include, e.g., UV LEDs and/or blue LEDs.

Referring to FIGS. **1**A, **2**A, and **2**B, for DC operation, e.g., the electrodes **130** and **132** may be electrically connected and/or receive a same first voltage while the electrodes **140** and **142** may be electrically connected and/or receive a same second voltage that is different from the first voltage. That is, e.g., a relationship between the electrode **130** and the other electrode **140** may be the same as a relationship between the electrode **132** and the electrode **142**. More particularly, a first voltage, e.g., negative or relatively low voltage, may be applied to electrodes **130** and **132**, and a second voltage, e.g., positive or relatively high voltage, may be applied to electrodes **140** and **142**. Referring to FIGS. **1**B, **2**A and **2**C, for AC operation, e.g., the electrodes **130** and **142** may be electrically connected and/or be in phase with each other while the electrodes **140** and **132** may be electrically connected and/or in phase with each other.

FIG. **3**A illustrates a perspective elevational view of an exemplary sub-mount **11** according to an exemplary embodiment. FIG. **3**B illustrates a partial schematic diagram, including mounting regions **180**, from a top of the sub-mount **11** of FIG. **3**A. FIG. **3**C illustrates a partial schematic diagram, including electrodes, from a top of the sub-mount **11** of FIG. **3**A. FIG. **3**D illustrates a schematic diagram of an exemplary arrangement of the mounting regions **180** of the sub-mount **11** of FIG. **3**A. FIG. **3**E illustrates a schematic diagram from a bottom of the sub-mount **11** of FIG. **3**A.

Referring to FIGS. **3**A through **3**E, the sub-mount **11** may include a base substrate **100**, the first pair of electrodes **130**, **140**, the second pair of electrodes **132**, **142**, a conductive pattern **110**, the mounting regions **180**, and vias **120**. Embodiments of the sub-mount **11** may provide the conductive pattern **110**, and the first and second pair of electrodes **130**, **140** and **132**, **142**, such that when elements, e.g., LEDs, are arranged on the mounting regions **180** of the sub-mount **11**, a device including the sub-mount **11** may be operated under one of AC or DC conditions when the sub-mount **11** is in a first position relative to a mounting substrate (not shown) of the device and may be operated under the other of AC or DC conditions by rearranging the sub-mount **11** relative to the mounting substrate (not shown), e.g., rotating, e.g., by 90 degrees, the sub-mount **11** to a second position relative to the mounting substrate (not shown).

The base substrate **100** may correspond to a body of the sub-mount **11**. The base substrate **100** may include, e.g., Si, strained Si, Si alloy, SOI, SiC, SiGe, SiGeC, Ge, Ge alloy, GaAs, InAs, AlN, polymer, plastic and/or ceramic, etc. The base substrate **100** may have any one of a variety of shapes, e.g., square, oval, etc.

The conductive pattern **110** may be arranged on a first surface **100***a* of the base substrate **100**. The conductive pattern **110** may include, e.g., Cu, Al, Ag, Au, W, Pt, Ti, Zn and/or Ni, etc. The first pair of electrodes **130**, **140** and the second pair of electrodes **132**, **142** may be arranged on a second surface **100***b* of the base substrate **100**. The first surface **100***a* may oppose the second surface **100***b*. The conductive pattern **110** and the vias **120** may enable elements, e.g., LEDs, to be arranged on the mounting regions **180** of the sub-mount to be electrically connected as shown in FIGS. **2**A and **2**B. The vias **120** may include a conductive material, e.g., metal.

More particularly, the conductive pattern **110** may include, e.g., mounting portions **112**, wiring portions **114**, and via portions **113**. The wiring portions **114** may connect respective mounting portions **112** together. The mounting portions **112** may connect adjacent ones of the mounting regions **180** together. The via portions **113** may respectively overlap the vias **120** and connect ones of the mounting portions **112** to a respective one of the electrodes, e.g., **130**, **132**, **140**, **142**.

Referring to FIGS. **3**B and **3**C, the mounting portions **112** may be arranged in a matrix pattern. More particularly, e.g., at least portions of the mounting portions **112** may be arranged in, e.g., a 2×2, 4×4, 8×8, 2×8, etc., matrix pattern.

Referring to FIG. **3**C, the mounting portions **112** may include a mounting sub-portion **112***a* and/or a connecting sub-portion **112***b*. In the exemplary embodiment of FIGS. **3**A through **3**C, the mounting portions **112** have a Y-like shape. More particularly, e.g., the mounting sub-portion **112***a* may have a V-like shape, and the connecting sub-portion **112***b* may be a stem portion extending towards an adjacent one of the mounting portions **112**. As shown in FIG. **3**C, the connecting sub-portion **112***b* may extend within a space defined by the mounting sub-portion **112***a* of the respective adjacent one of the mounting portions **112**. In embodiments, e.g., one or more of the connecting sub-portions **112***b* may include end portions **112***c* having, e.g., an arrow like shape and/or one or more of the connecting sub-portions **112***b* may continuously connect to respective wiring portions **114**. More particularly, e.g., in embodiments, the connecting sub-portions **112***b* may connect adjacent ones of the mounting sub-portions **112***a* together while the wiring portions **114** may connect together corresponding ones of the mounting sub-portions **112***a* that are not adjacent to each other.

As shown in FIGS. **3**B and **3**C, each of the mounting regions **180** may be associated with respective ones of the mounting portions **112**. In embodiments, each of the mounting portions **112** may be associated with two adjacent ones of the mounting regions **180** so as to provide a conductive path adapted to connect corresponding adjacent ones of the mounting portions **112** in series. More particularly, as shown in FIG. **3**B, each of the mounting regions **180** may be include at least a portion of a respective one of the mounting portions **112**, e.g., respective mounting sub-region **112***a*, and/or a respective one of the connecting sub-portions **112***b* of another of the mounting portions **112**.

Further, referring to FIGS. **3**C and **3**D, in embodiments, the mounting sub-portions **112***a* may define a matrix pattern. That is, e.g., the mounting sub-portions **112***a* may be arranged in rows extending along a first direction DR**1** and columns extending along a second direction DR**2**. The connecting sub-portions **112***b* may extend between two adjacent mounting portions **112***a* along a third direction DR**3**.

Referring to FIG. **3**D, the plurality of mounting regions **180** of the sub-mount **11** may correspond to a matrix pattern. Each of the mounting sub-portions **112***a* may be in a respective one of the mounting regions **180** of the base substrate **100**. Referring to FIG. **3**D and FIGS. **2**A and **2**B, in such embodiments, a plurality of the mounting regions **180** extending along a same diagonal path may be connected in series. That is, e.g., in the exemplary embodiment of FIG. **3**D with five diagonal lines L**1**, L**2**, L**3**, L**4** and L**5** of mounting regions **180** extending along the third direction DR**3**, the respective connecting sub-portions **112***b* may electrically connect adjacent ones of the mounting regions **180** along the third direction DR**3**. In embodiments, e.g., embodiments corresponding to FIGS. **2**A and **2**B, the (0,2), (1,3), (3,3), (2,2), (1,1), (0,0), (2,0) and (3,1) mounting regions **180** may be electrically connected in series via the respective mounting regions **180** at least when elements are respectively mounted thereon. Further, in such embodiments, e.g., the (2, 3), (1, 2), (0, 1), (0, 3), (3,0), (3,2), (2,1) and (1,0) mounting regions **180** may be electrically connected in series via the respective mounting regions **180** at least when elements are respectively mounted thereon.

In the exemplary embodiment of FIG. **3**C, the connecting sub-portions **112***b* may extend along the third direction DR**3**. However, embodiments are not limited thereto as, e.g., the connecting sub-portions **112***b* may have a different shape, e.g., non-linear shape. Further, as shown in FIG. **3**C, the connecting sub-portions **112***b* may be inherently/directly connected to the mounting sub-portion **112***a* of one of the mounting portions **112** and may be spaced apart from the mounting sub-portion **112***a* of the adjacent one of the mounting portions **112** along the third direction DR**3**. The third direction DR**3** may form an acute angle with respect to each of the first direction DR**1** and the second direction DR**2**.

Referring to FIGS. **3**A, **3**C and **3**E, each of the pairs of electrodes **130**, **140** and **132**, **142** may include a first electrode, e.g., **130**, **132**, and a second electrode, e.g., **140**, **142**. Each of the electrodes **130**, **132**, **140**, **142** may be connected to a respective portion of the conductive pattern **110** by way of one or more of the vias **120**. The electrodes **130**, **132**, **140**, **142** may be arranged, e.g., in a matrix pattern on the second surface **100***b* of the base substrate **100**. More particularly, e.g., the electrodes **130**, **132**, **140**, **142** may be arranged in, e.g., a 2×2, 1×4, 4×1, 3×3, 4×4, etc., matrix pattern.

In embodiments, the corresponding first and second electrodes of each of the first and second electrode pairs **130** and **140**, **132** and **142** may be arranged so as to be in different columns and rows. For example, the corresponding first and second electrodes of the first electrode pair **130**, **140** may be arranged at a diagonal relative to each other on the second surface **100***b* of the base substrate **100**, and the corresponding first and second electrodes of the second electrode pair **32**, **142** may be arranged at a diagonal relative to each other on the second surface **100***b* of the base substrate **100**. Although FIG. **3**C illustrates the electrodes **130**, **132**, **140**, **142** arranged in a matrix pattern, embodiments are not limited thereto. For example, other arrangements enabling elements to be mounted on the mounting regions **180** between the electrodes **130**, **132**, **140**, **142** to be electrically connected as shown in FIGS. **2**A and **2**B may be employed.

More particularly, e.g., LEDs, e.g., **190**, may be mounted on mounting regions **180** of the sub-mount **11**, and the sub-mount **11** may enable corresponding ones of the mounting portions **112** may be connected in series between each of the electrode pairs **130**, **140** and **132**, **142**. Referring to FIGS. **2**A and **2**B and **3**A through **3**E, corresponding ones of the mounting portions **112** and the first group of LEDs **190***a* along the path between the first electrode pair **130**, **140** may be driven based on voltages applied to the electrodes of the first electrode pair **130**, **140**. The corresponding ones of the mounting portions **112** and the second group of LEDs **190***b* along the path between the second electrode pair **132**, **142** may be driven based on voltage applied to the electrodes of the second electrode pair **132**, **142**.

Each of the electrodes **130**, **132**, **140**, **142** may overlap with a plurality of the mounting regions **180**. In embodiments, the electrodes **130**, **132**, **140**, **142** may cover an amount of the second surface **100***b* corresponding to a general size of the conductive pattern **110**, e.g., may cover a majority and/or all of the second surface **100***b* directly below, i.e., overlapping, the conductive pattern **110** on the first surface **100***a*.

Each of the electrodes **130**, **132**, **140**, **142** may be connected by way of, e.g., the respective via **120**, to corresponding via portions **113** of the conductive pattern **110**. When elements, e.g., LEDs, are mounted on the sub-mount **11**, the via portions **113** of the conductive pattern **110** may be connected to respective ones of the mounting portions **112**.

The vias **120** may extend through the base substrate **100**. More particularly, e.g., the vias **120** may extend from the first surface **100***a* to the second surface **100***b*. The vias **120** may provide a conductive path between the electrodes **130**, **132**, **140**, **142** and respective ones of the mounting regions **180**.

Referring to FIGS. **3**A through **3**D, LEDs may be mounted onto the base substrate **100** at the mounting regions **180**. More particularly, e.g., LEDs **190***a*, **190***b* of FIG. **2**A may be mounted on to the mounting regions **180** of the base substrate **100**.

FIG. **4** illustrates a flow chart of an exemplary method of forming the exemplary sub-mount **11** of FIGS. **3**A-**3**E according to an exemplary embodiment. Formation of the sub-mount **11** may begin at S**100**. Referring to FIGS. **3**A through **3**E and **4**, during S**200**, the vias **120** may be formed in the base substrate **100**. The vias **120** may be formed by selectively masking the base substrate **100** and then removing, e.g., etching, the selectively masked substrate to generate openings in the substrate **100** in which conductive material may be filled. During **5300**, the conductive pattern **110** may be formed on the first surface **100***a* of the base substrate **100**. As described above, the conductive pattern **100** may include a plurality of the mounting portions **112**, the via portions **113** and/or the wiring portions **114**. During S**400**, the plurality of electrode pairs **130**, **140** and **132**, **142** may be formed on the second surface **100***b* of the base substrate **100**. At **5500**, formation of the sub-mount **11** may be complete.

FIG. **5** illustrates a schematic diagram of electrical paths between two pairs of electrodes of a light emitting device **2** according to another exemplary embodiment. In general, only differences between the exemplary embodiment illustrated in FIG. **5** and the exemplary embodiment of FIGS. **2**A and **2**B will be described below, and like reference numerals correspond to like elements. Referring to FIG. **5**, in embodiments, the light emitting device **2** may include a plurality of LEDs **290** electrically connected between at least two pairs of electrodes **230**, **240** and **232**, **242**. In contrast to the exemplary embodiment of FIGS. **2**A and **2**B in which all the LEDs **190** are connected in series between the respective pair of electrodes **130**, **140** and **132**, **142**, in the exemplary embodiment of FIG. **5**, the LEDs **290** may be electrically connected in series and/or parallel.

FIGS. **6**A and **6**B illustrate planar view from a top of an exemplary sub-mount **22** without and with the LEDs **290** mounted thereon, respectively, according to an exemplary embodiment that may be employed to implement the electrical paths illustrated in FIG. **5**. In general, only differences between the exemplary embodiment illustrated in FIGS. **6**A and 6B and the exemplary embodiment of FIGS. 3A through 3E will be described below, and like reference numerals correspond to like elements.

Referring to FIGS. 6A and 6B, the sub-mount 22 may include a conductive pattern 210, vias 220, the plurality of pairs of electrodes 230, 240 and 232, 242, and a plurality of mounting regions 280. The conductive pattern 210 may be arranged on a first surface of a substrate 200 and the two pairs of electrodes 230, 240 and 232, 242 may be arranged on a second surface of the substrate 200 that opposes the first surface. The vias 220 may extend through the substrate 200 between the first surface and the second surface thereof.

The conductive pattern 210 may include mounting portions 212 and wiring portions 214. In embodiments, the conductive pattern 210, the vias 220 and the electrodes 230, 232, 240, 242 may be arranged so as to enable the LEDs 290 to be mounted on the sub-mount 22 to be electrically connected as shown in FIG. 5. Thus, in the exemplary embodiment of FIGS. 6A and 6B, the conductive pattern 210, and more particularly, the mounting portions 212 and the wiring portions 214 may have a pattern that enables the serial and/or parallel connections shown in FIG. 5. The wiring portions 214 may connect respective ones of the mounting portions 212 together.

Referring to FIG. 6A, each of the mounting portions 212 may include a plurality of mounting sub-portions, e.g., first, second and third mounting sub-portions 212*a*, 212*b*, 212*c*. In the exemplary embodiment of FIG. 6A, the first mounting sub-portion 212*a* has an E-like shape, and the second mounting sub-portions 212*b* includes an E-like shaped portion and an inverse-E-like shaped portion. In the exemplary embodiment of FIG. 6A, the inverse-E-like shaped portion may substantially correspond to a portion of the second mounting sub-portion 212*b* having a shape complementary to prongs of the E-like shaped first mounting sub-portions 212*a*. Further, in the exemplary embodiment of FIG. 6A, the third mounting sub-portion 212*c* may have an inverse-E-like shape that is complementary to prongs of the E-like shaped portion of the second mounting sub-portion 212*b*. The first, second and third mounting sub-portions 212*a*, 212*b*, 212*c* of each mounting portion 212 may be arranged so as to be spaced apart from each other, but relatively close together so as to generally define a substantially continuous unified shape, e.g., a square, rectangle, etc. The mounting sub-portions 212*a*, 212*b*, 212*c* of each of the mounting portions 212 may be connected through the respective LEDs 290 that may be mounted on to the mounting regions 280.

In the exemplary embodiment illustrated in FIGS. 6A and 6B, each of the mounting portions 212 may be associated with four of the LEDs 290 and may be respectively arranged on four mounting regions 280 of the respective mounting portion 212.

Referring to FIG. 6B, the pairs of electrodes 230, 240 and 232, 242 may be arranged on the second surface of the substrate 200 in a manner similar to that of the pairs of electrodes 130, 140 and 132, 142 of FIGS. 3A through 3E.

In embodiments, the plurality of electrode pairs, e.g., the two pairs of electrodes 130, 140 and 132, 142 may be driven in a manner that enables the LEDs 290 mounted on the sub-mount 22 to operate under both AC and DC conditions. More particularly, e.g., in embodiments, the plurality of electrode pairs, e.g., the two pairs of electrodes 130, 140 and 132, 142 may be driven in a manner that enables the LEDs 290 that may be mounted on the sub-mount 22 to operate under both AC and DC conditions by, e.g., rotating the mounting substrate. In the exemplary embodiment of FIGS. 5, 6A and 6B, eight LEDs 290*a* are illustrated between the first pair of electrodes 230, 240 and eight LEDs 290*b* are illustrated between the second pair of electrodes 232, 242. Embodiments are not limited, however, to having eight LEDs between the pairs of electrodes. For example, as described below, FIGS. 7 and 8 illustrate embodiments including thirty-two LEDs.

Further, in the exemplary embodiments illustrated in FIGS. 3A through 3E, 6A and 6B, the sub-mounts 11, 22 each include 16 mounting regions 180, 280, respectively. Embodiments are not limited, however, to having, e.g., 16 mounting regions 180, 280.

FIG. 7 illustrates a schematic diagram of electrical paths between two pairs of electrodes of a light emitting device 12' according to another exemplary embodiment. The exemplary light emitting device 12' of FIG. 7 substantially corresponds to the exemplary light emitting device 12 of FIG. 5, but including thirty-two LEDs 290*a* between the first pair of electrodes 230, 240 and thirty-two LEDs 290*b* between the second pair of electrodes 232, 242. Accordingly, the exemplary light emitting device 12 of FIG. 5 may include sixty-four LEDs 290.

FIG. 8 illustrates a schematic diagram from a top of an exemplary sub-mount 22' according to another exemplary embodiment. The exemplary sub-mount 22' of FIG. 7 substantially corresponds to the exemplary sub-mount 12 of FIGS. 6A and 6B, but including thirty-two LEDs 290*a*, in contrast to eight LEDs, between the first pair of electrodes 230, 240 and thirty-two LEDs 290*b* between the second pair of electrodes 232, 242. The sub-mount 22' may include a conductive pattern 210', vias 220 and the pairs of electrodes 130, 140 and 132, 142. The conductive pattern 210' may include the mounting portions 212 and a wiring region 214'. As shown in FIG. 8, the wiring region 214' may be arranged so as to connect the mounting portions 212 together in groups of eight mounting portions 212.

FIGS. 9A and 9B illustrate schematic diagrams of electrical paths of light emitting devices 17*ac*, 17*dc* adapted for AC and DC operation, respectively. Referring to FIGS. 9A and 9B, the light emitting devices 17*ac*, 17*dc* may include a plurality of groups, e.g., two groups, of the light emitting devices 1 including sub-mounts 1_1, 1_2, 1_3, 1_4 one or more of which may correspond, e.g., to the sub-mount 11, of FIGS. 2A, 2B and 3A through 3D, arranged between two nodes, e.g., two power supplies 310, 320. More particularly, e.g., in the exemplary embodiments of FIGS. 9A and 9B, each of the light emitting devices 17*ac*, 17*dc* includes, e.g., four of the light emitting devices 1 of FIG. 1 arranged in series between the two power supplies 310, 320. More particularly, e.g., each of the light emitting device 17*ac*, 17*dc* may include, e.g., a first group of thirty-two LEDs between the two power supplies 310, 320 along a first path connected by connecting portions 312, 314, 316 and a second group of thirty-two LEDs between the two power supplies 310, 320 along a second path connected by connecting portions 322, 324, 326.

FIG. 10A illustrates a block diagram of a circuit substrate employable for implementing the exemplary light emitting devices 17*ac*, 17*dc* of FIGS. 9A and 9B according to an exemplary embodiment. Referring to FIG. 10A through 10C, the circuit substrate 300 may include a power supply pattern 310, a second power supply pattern 320, a plurality of connecting patterns 312', 314', 316', 322', 324', and 326', and a plurality of sub-mounts 1_1, 1_2, 1_3, 1_4 arranged thereon. The sub-mounts 1_1, 1_2, 1_3, 1_4 may each correspond to the sub-mount 11 of FIG. 3A through 3E. More particularly, referring to FIGS. 9A, 9B, 10A, 10B and 10C, the connecting portions 312, 314, 316, 322, 324, 326 may respectively correspond to the connecting patterns 312', 314', 316', 322', 324', 326'. The two power supplies **310**, **320** may correspond to the first power supply pattern **310'** and the second power supply pattern **320'**.

More particularly, referring to FIG. **10**A, the first power supply pattern **310'**, the second power supply pattern **320'**, and the connecting patterns **312'**, **314'**, **316'**, **322'**, **324'**, **326'** may be arranged on the circuit substrate **300**. The connecting patterns **312'**, **314'**, **316'**, **322'**, **324'**, **326'** may be arranged so as to be along an electrical path between the first power supply pattern **310** and the second power supply pattern **320**. Referring to FIG. **10**A, the connecting patterns **312'**, **314'**, **316'**, **322'**, **324'**, **326'** may form a substantially U-like shape between the first power supply pattern **310'** and the second power supply pattern **320'**. The first and second power supply patterns **310**, **320** and the connecting patterns **312'**, **314'**, **316'**, **322'**, **324'**, **326'** may each have, e.g., a polygonal, e.g., square, rectangular shape. The first and second power supply patterns **310'**, **320'** and the connecting patterns **312'**, **314'**, **316'**, **322'**, **324'**, **326'** may be spaced apart from each other on the circuit substrate **300**.

FIGS. **10**B and **10**C illustrate block diagrams of the circuit substrate of FIG. **10**A including the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** mounted thereon for AC and DC operation of the light emitting devices of FIGS. **9**A and **9**B, respectively, according to another exemplary embodiment. The light emitting devices **17***ac*, **17***dc* may substantially correspond to each other, but for the arrangement of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** relative to the circuit substrate **300**. More particularly, e.g., the light emitting devices **17***ac*, **17***dc* of FIGS. **10**B and **10**C may be the same, other than each of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** being rotated 90 degrees relative to the circuit substrate **300**.

More particularly, for AC operation with the circuit substrate **300** of FIG. **10**A, e.g., as shown in FIG. **10**B, the sub-mount **1_1** may be arranged such that electrodes **132**, **140** may be electrically connected to the first power supply pattern **310** and the electrodes **130**, **142** may be arranged such that the electrodes **130**, **142** may be electrically connected to the connecting patterns **312**, **326**, respectively. For DC operation with the circuit substrate **300**, the sub-mount **1_1** may be arranged such that electrodes **142**, **140** are electrically connected to the first power supply pattern **310** and the electrodes **130**, **132** may be arranged such that the electrodes **130**, **132** are electrically connected to the connecting patterns **312**, **326**, respectively. That is, e.g., for both AC and DC operation using the circuit substrate **300**, the sub-mount **1_1** may be electrically connected to the same first power supply pattern **310** and the same connecting patterns **312**, **326**, but may be rotated, e.g., by 90 degrees, such that different electrodes of the sub-mount **1_1** are connected to the first power supply pattern **310** and the same connecting patterns **312**, **326** for AC and DC operation.

Referring still to FIGS. **10**B and **10**C, e.g., for AC operation with the light emitting device **17***ac*, the sub-mount **1_2** may be arranged such that electrodes **132**, **140** are electrically connected to the connecting patterns **326**, **312**, respectively, and the electrodes **130**, **142** are electrically connected to the connecting patterns **324**, **314** respectively. In contrast, for DC operation with the light emitting device **17***dc*, the sub-mount **1_2** may be arranged such that electrodes **140**, **142** are electrically connected to the connecting patterns **326**, **312**, respectively, and the electrodes **130**, **132** are electrically connected to the connecting patterns **324**, **314**, respectively. That is, e.g., for both AC and DC operation using the circuit substrate **300**, the sub-mount **12** may be electrically connected to the same connecting patterns **312**, **314**, **324**, **326**, but may be rotated, e.g., by 90 degrees, such that different electrodes of the sub-mount **1_1** are connected to connecting patterns **312**, **314**, **324**, **326** for AC and DC operation.

Referring still to FIGS. **10**B and **10**C, e.g., for AC operation with the light emitting device **17***ac*, the sub-mount **1_3** may be arranged such that electrodes **140**, **132** are electrically connected to the connecting patterns **314**, **324**, respectively, and the electrodes **130**, **142** are electrically connected to the connecting patterns **316**, **322** respectively. In contrast, for DC operation with the light emitting device **17***dc*, the sub-mount **1_3** may be arranged such that electrodes **140**, **142** are electrically connected to the connecting patterns **324**, **314**, respectively, and the electrodes **130**, **132** are electrically connected to the connecting patterns **322**, **316**, respectively. That is, e.g., for both AC and DC operation using the circuit substrate **300**, the sub-mount **1_3** may be electrically connected to the same connecting patterns **314**, **316**, **322**, **324** but may be rotated, e.g., by 90 degrees, such that different electrodes of the sub-mount **1_1** are connected to connecting patterns **314**, **316**, **322**, **324** for AC and DC operation.

More particularly, for AC operation with the circuit substrate **300** of FIG. **10**A, e.g., as shown in FIG. **10**B, the sub-mount **1_4** may be arranged such that electrodes **132**, **140** may be electrically connected to the connecting patterns **322**, **316**, respectively, and the electrodes **130**, **142** may be electrically connected to the second power supply pattern **320**. For DC operation with the circuit substrate **300**, the sub-mount **1_4** may be arranged such that electrodes **142**, **130** are electrically connected to the second power supply pattern **320** and the electrodes **132**, **140** may be arranged such that the electrodes **132**, **140** are electrically connected to the connecting patterns **322**, **316**, respectively. That is, e.g., for both AC and DC operation using the circuit substrate **300**, the sub-mount **14** may be electrically connected to the same second power supply pattern **320** and the same connecting patterns **322**, **316**, but may be rotated, e.g., by 90 degrees, such that different electrodes of the sub-mount **14** are connected to the second power supply pattern **320** and the same connecting patterns **322**, **316** for AC and DC operation.

Accordingly, as shown in FIGS. **10**A through **10**C, embodiments may provide a circuit substrate **300**, which may be employed with same sub-mounts, e.g., **1_1**, **1_2**, **1_3**, **1_4** that are merely positioned differently, e.g., rotated 90 degrees, depending on whether the resulting device, e.g., **17***ac*, **17***dc*, is DC or AC operated.

FIGS. **11**A and **11**B illustrate schematic diagrams of electrical paths of light emitting devices **19***ac*, **19***dc* adapted for AC and DC operation, respectively. FIGS. **12**A and **12**B illustrate block diagrams of the exemplary arrangement of sub-mounts **1_1**, **1_2**, **1_3**, **1_4** on power supply electrodes **410**, **420** for implementing the light emitting devices **19***ac*, **19***dc* of FIGS. **11**A and **11**B, respectively, according to another exemplary embodiment.

Referring to FIGS. **11**A and **11**B, the light emitting devices **19***ac*, **19***dc* may include a plurality of groups, e.g., two groups, of the light emitting devices **1** including sub-mounts **1_1**, **1_2**, **13**, **1_4**, one or more of which may correspond, e.g., to the sub-mount **11**, of FIGS. **2**A and **2**B and **3**A through **3**D, arranged between two nodes, e.g., two power supply electrodes **410**, **420**. Referring to FIGS. **11**A and **11**B, the light emitting devices **19***ac*, **19***dc* may include a plurality of groups, e.g., two groups, of the light emitting devices **1** including sub-mounts **11** of FIGS. **2**A and **2**B and **3**A through **3**D arranged between two nodes, e.g., the two power supplies **410**, **420**. More particularly, e.g., in the exemplary embodiment, each of the light emitting devices **19***ac*, **19***dc* includes, e.g., four of the light emitting devices **1** of FIG. **1** arranged in parallel between the two power supply electrodes **410**, **420**.

In the exemplary embodiments of FIGS. **12**A and **12**B, the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** are connected to the power supply electrodes **410**, **420**. The power supply electrodes **410**, **420** may be arranged on a substrate (not shown). For AC operation, as shown in FIG. **12**A, the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** may be arranged such that the electrodes **140**, **142** of each of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** is connected to the first power supply electrode **410**, and the electrodes **130**, **132** of each of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** is connected to the second power supply electrode **420**.

For DC operation, as shown in FIG. **12**B, the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** may be arranged such that the electrodes **130**, **142** of each of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** is connected to the first power supply electrode **410**, and the electrodes **140**, **132** of each of the sub-mounts **1_1**, **1_2**, **1_3**, **1_4** is connected to the second power supply electrode **420**. In such embodiments, no other conductive patterns need be employed to connect electrically connect the respective electrodes **130**, **132**, **140**, **142** of the sub-mount **11** to the first and second power supply electrodes **410**, **420**.

FIG. **13** illustrates an elevational schematic diagram of an exemplary light emitting device **14** including the sub-mount **11** of FIGS. **3**A through **3**E. Referring to FIG. **13**, the light emitting device **14** may include, e.g., the sub-mount of FIGS. **3**A through **3**E arranged on leads **514***a*, **514***b* exposed by a slot **512** within a package body **510**.

As discussed above, a plurality of LEDs **190** may be mounted on the sub-mount **11**. Two of the electrodes, e.g., **140**, **132** may be connected to one of the leads **514***a* and two of the electrodes, e.g., **142**, **130**, may be connected to the other of the leads **514***b*. The leads **514***a*, **514***b* may be electrically connected to the respective LEDs **190** by way of the electrodes **130**, **132**, **140**, **142** and the vias **120** of the sub-mount **11**.

As shown in FIG. **13**, sides of the slot **512** may be oblique and light generated by the LEDs **190** may be reflected at the sides of the slot **512**. The package body **510** may include, e.g., Si resin, epoxy resin, acrylic resin, glass and/or silica, etc.

FIGS. **14**A, **14**B, and **14**C illustrate cross-sectional views of the exemplary light emitting device **14***a*, **14***b*, **14***c* of FIG. **13** including exemplary arrangements of phosphor **264** therein. The light emitting device **14***a*, **14***b*, **14***c* may include transparent resin **250** and a phosphor layer **260**. The phosphor layer **260** may include transparent resin **262** with the phosphor **264** dispersed therein. More particularly, the phosphor **265** may be dispersed on and/or within the transparent resin **262** of the phosphor layer **260**. The phosphor **264** may include, e.g., nitride/oxide material that may be activated by a lanthanide, e.g., Eu, Ce, etc. The phosphor **264** may absorb light generated by the LEDs **190** and may convert the wavelength of the light. The transparent resin **250**, **262** may include, e.g., epoxy resin, acrylic resin, and/or urethane resin, etc. The package body **510** may include and/or be arranged on a substrate **500**.

As shown in FIG. **14**A, in embodiments, a transparent resin **250** may partially fill the slot **512** and a phosphor layer **260***a* may be arranged the transparent resin **250** at an upper portion of the slot **512**. The light emitting device **14***a* may also include a filter **280** on the phosphor layer **260***a*. The filter **280** may absorb light having a predetermined wavelength. In embodiments in which the light emitting devices **190** are UV light emitting devices, the filter **280** may be a UV filter. As shown in FIG. **14**B, in embodiments, a transparent resin **250***b* may completely fill the slot **512** and a phosphor layer **260***b* may be arranged on the transparent resin **250***b*. The phosphor layer **260***b* may be a lens type structure having a predetermined curvature to improve a quality of light emission/extraction.

As shown in FIG. **14**C, in embodiments, a transparent resin **250***c* may be formed only on the sub-mount **11**, and a phosphor layer **260***c* may fill the slot **512**.

FIGS. **15**A and **15**B illustrate exemplary arrangements of a phosphor layer **340** on the circuit substrate **300** of FIGS. **10**A through **10**C. In embodiments, e.g., the phosphor layer **340** may include a transparent resin **350** including phosphor dispersed therein. FIG. **15**A illustrates a line-type phosphor layer **340***a* and a line-type transparent resin layer **350***a* on the circuit substrate **300**. FIG. **15**B illustrates a dot-type phosphor layer **340***b* and a dot-type transparent resin layer **350***b* on the circuit substrate **300**.

FIGS. **16**A, **16**B, **16**C, **16**D, and **16**E illustrate various exemplary illuminating devices employing a light emitting device according to one or more aspects of the invention. For example, FIG. **16**A illustrates a back light including the light emitting device **14***a* of FIG. **14**A. The back light may include the light emitting device **14***a* of FIG. **14**A, a reflective sheet **412**, a pattern **412***a*, a spreading sheet **414**, a prism sheet(s) **416** and a display panel **450**. FIG. **16**B illustrates a projector including a light source **510** that may include, e.g., the light emitting device **14***c* of FIG. **14**C. the projector may further include a condensing lens **520**, a color filter **530**, a shaping lens **540**, a digital micromirror device (DMD) **550**, and a projection lens **580**. FIG. **16**C illustrates exemplary illuminating devices employing LEDs **190** arranged on sub-mount, e.g., sub-mount **11** of FIGS. **3**A through **3**E, the sub-mount **22** of FIG. **5**, the circuit substrate **300** of FIG. **10**A, and/or the power supply electrodes **310**, **410** of FIGS. **12**A, **12**B. More particularly, FIGS. **16**A, **16**B, and **16**C illustrate an automobile head lamp, a street lamp and an illumination light, respectively, which may each include one or more of the light emitting device(s), e.g., **17***ac*, **17***dc* of FIGS. **10**B and **10**C, respectively, to project light.

Further, although, e.g., sub-mount **11** of FIGS. **3**A through **3**E may be employed in the description of various exemplary applications and/or devices, it should be understood that a sub-mount according to any one or more of the aspects described above may be employed in the various exemplary applications and/or devices. That is, embodiments are not limited to those explicitly illustrated in the accompanying Figures.

It should be recognized that well known modifications can be made to configure the exemplary embodiments to become more suitable for use in a variety of applications. The modifications may include, for example, elimination of unnecessary components, addition of specialized devices or circuits, and/or integration of a plurality of devices.

Exemplary embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. Accordingly, it will be understood by those of ordinary skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present invention as set forth in the following claims.

What is claimed is:

1. A sub-mount comprising:

a base substrate having a plurality of vias extending through the base substrate;

a plurality of mounting portions formed on a first surface of the base substrate and on which at least one light emitting element is mounted, at least one mounting portion being electrically connected with more than one light emitting elements;

wiring portions to connect respective mounting portions together;

a transparent resin layer formed on a phosphor layer on the at least one light emitting element and the mounting portions; and

first and second electrode pads formed on a second surface of the base substrate and electrically connected to the mounting portions,

wherein the plurality of mounting portions are arranged in a matrix pattern along a first direction and a second direction,

wherein at least a portion of the wiring portions connect the plurality of mounting portions along a third direction formed at an acute angle with respect to each of the first direction and the second direction.

2. The sub-mount of claim **1**, wherein the base substrate includes at least one of silicon (Si), strained Si, Si alloy, silicon-on-insulator (SOI), silicon carbide (SiC), silicon germanium (SiGe), silicon germanium carbide (SiGeC), germanium (Ge), Ge alloy, gallium arsenide (GaAs), indium arsenide (InAs), aluminum nitride (AlN), polymer, ceramic, plastic, a combination thereof, and a laminate thereof.

3. The sub-mount of claim **1**, wherein the first and second electrode pads include at least one of copper (Cu), aluminum (Al), silver (Ag), gold (Au), tungsten (W), platinum (Pt), tin (Ti), zinc (Zn), nickel (Ni), a combination thereof, and a laminate thereof.

4. The sub-mount of claim **1**, wherein the light emitting element is at least one of a UV light emitting device generating UV light and a blue light emitting device generating blue light that is light having a blue wavelength.

5. The sub-mount of claim **1**, wherein the light emitting element is a flip chip type light emitting element.

6. The sub-mount of claim **1**, wherein the phosphor layer is a material which absorbs light from the light emitting element and converts the light into light having a different wavelength, and includes at least one selected from the group consisting of a nitride-based or oxynitride-based phosphor, mainly activated by lanthanoids such as Eu and Ce.

7. The sub-mount of claim **1**, wherein the phosphor layer is conformally formed on the light emitting element.

8. A sub-mount comprising:

a base substrate having a plurality of vias extending through the base substrate;

a mounting portion formed on a first surface of the base substrate and on which more than one light emitting elements are mounted;

wiring portions to connect respective mounting portions together;

a transparent resin layer formed on a phosphor layer on the light emitting elements and the mounting portion; and

first and second electrode pads formed on a second surface of the base substrate and electrically connected to the mounting portion,

the plurality of vias electrically connecting the light emitting elements to the first and second electrode pads,

wherein the plurality of mounting portions are arranged in a matrix pattern along a first direction and a second direction,

wherein at least a portion of the wiring portions connect the plurality of mounting portions along a third direction formed at an acute angle with respect to each of the first direction and the second direction.

9. The sub-mount of claim **8**, further comprising conductive patterns on the first surface of the base substrate between the light emitting elements and the base substrate, the conductive patterns electrically connected to the light emitting elements and the base substrate, the plurality of vias electrically connecting the conductive patterns to the first and second electrode pads.

* * * * *